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Literature on Philippine fisheries is extensive and scattered. It covers various fields of fisheries science, such as technology, biology, planktology, algology, ichthyology, carcinology, conchology, and oceanography which have been investigated and studied by Filipino research workers and foreign scientists. The scientific papers prepared as a result of such investigations and studies were, therefore, published in this country and abroad. With the creation of the Philippine Bureau of Fisheries, the implementation of the Philippine Fishery Program under the United States Fish and Wildlife Service, the organization of the Fisheries Society of the Philippines, and the membership of the Philippine Republic in the Indo-Pacific Fisheries Council, there has developed a keen interest among our technical men to engage in fisheries research.

This bibliography will serve as a ready reference to these workers and to others who may be interested to have access to such publications. Although most of the publications in our private collections and in Government libraries have been lost as a consequence of World War II, we may recover some if not all of them through the use of this bibliography which contains references published as far back as 1865.

[1] Manuscript submitted to the 3rd Meeting, Indo-Pacific Fisheries Council at Madras, India, February 1–16, 1951.

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THE THERMAL STRUCTURE OF THE SURFACE WATERS OFF WESTERN PHILIPPINES BASED ON BT OBSERVATIONS

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EIGHT TEXT FIGURES

Within the lighted portion of the water column in Philippine waters there are two distinct layers easily distinguishable by their thermal structure. Superimposed upon the discontinuity layer or the main thermocline is the mixed or isothermal layer of uniformly high temperature. Owing to phytoplankton activity, the isothermal layer is generally deficient in the chemical nutrients known to regulate and limit plant growth. The thermocline below militates against the vertical movements of the richer waters beneath it, as a consequence of which there is no active replenishment of the impoverished waters within the isothermal layer.

While it is highly desirable to study the thermal structure of both layers in order to acquire a more thorough understanding of the mechanisms controlling nutrient exchange, the BT (bathythermograph) tows did not penetrate deep enough to reach the lower boundary of the main thermocline. The maximum BT penetration never exceeded 150 meters. Below this depth there were still evident significant temperature gradients as shown by the vertical temperature distribution curves based on the hydrographic data.

To conform with the standard units adopted by the Indo-Pacific Fisheries Council with which the Philippines is affiliated, the BT measurements of temperature and depth are expressed in the metric system. The conversion facilitated the scaling of values corresponding to the standard depths adopted in the reduction of the hydrographic data, thus permitting comparison between the two types of data.

Except for a few stations occupied during the first part of the survey, the BT observations were made at points approximately midway between pairs of successive stations.

The data used in this study were collected by the *Spencer F. Baird* of the United States Fish and Wildlife Service in July and August, 1949 at the height of the southwest monsoon period. The survey was completed in a single cruise of 24 days.

Though the data at hand are not by any means complete as to provide a closer coverage of the area under study and comprehensive enough as to present fully the average condition of temperature during the southwest monsoon period, the results yield valuable information that permits the drawing of general conclusions.

SOURCES OF ERROR

Two bathythermographs were used, the first having been lost overboard at BT–861 when rough seas were encountered during the first leg of the survey. The performance of the two instruments was satisfactory throughout except in one instance at BT–836 where the lost BT showed an apparent shift in its "zero point". While a shift in the zero point does not affect the shape of any given trace, wide deviations from the reversing thermometer temperature reading should amply warn of the necessity for adjustment or repair of the instrument. Owing to the fact that a different calibration grid was used in scaling values from the traces recorded by one of the two bathythermographs, there may be a systematic error in the absolute values of the temperature data. Since, however, all the BT temperatures were referred to the hydrographic data, such error can be expected to be of little significance. Due to the limitations in the accuracy of the instrument and the conversion of values from one unit to another, the temperature values may deviate as much as 0.2° C. and the depths not greater than five meters from their true values. These errors, however, are within the accuracy required.

REDUCTION PROCEDURE

The conversion of depth in feet into the metric unit was effected by using a transparent sheet upon which the lateral grid lines were etched to correspond to depths expressed in meters. Temperature values scaled to the nearest 0.1° F. were converted to ° C. and later corrected for the difference between the BT reading and the mean of the two reversing thermometer surface readings taken from the nearest pair of consecutive hydrographic stations. If both types of observations were made in the same station, the correction was based on only one reading. In either case this correction was applied to all the BT readings corresponding to the other standard depths. The converted values appear under each station in Table 1.

TABLE 1.—*Corrected temperatures in °C corresponding to standard depths expressed in meters*

Depth	BT—820	—822	—824	—826	—829	—833	—836	—843	—846
0	29.4	29.4	29.3	29.3	29.5	30.0	29.1	29.4	29.1
25	29.2	29.3	29.3	29.2	29.5	29.9	29.1	29.6	29.1
50	27.8	28.7	29.3	28.9	29.1	29.2	28.8	28.5	27.0
75	24.0	22.2	23.8	21.6	25.4	22.9	------	24.5	24.0
100	24.0	19.5	------	19.5	21.1	20.5	------	21.3	------
125	------	16.6	------	------	------	------	------	------	------

	—848	—850	—855	—861	—863	—865	—867	—869	—871
0	29.1	28.8	28.5	29.3	29.7	29.5	29.1	29.4	29.6
25	29.1	28.8	28.5	29.2	29.6	28.3	28.7	29.1	29.3
50	28.6	28.7	28.1	29.0	29.5	28.3	28.5	28.9	27.0
75	23.9	-----	26.7	26.9	26.9	26.9	25.4	22.9	23.6
100	------	------	24.6	25.0	23.6	24.5	23.2	20.4	------
125	------	-----	20.7	20.9	------	21.2	------	------	------

	—873	—876	—878	—880	—833	—885	—890	—892	—894
0	29.4	29.4	29.5	29.3	29.3	29.3	29.1	29.5	29.7
25	29.1	29.2	29.3	29.0	29.1	28.8	28.5	28.7	29.4
50	25.4	28.4	29.2	28.0	27.5	28.2	27.1	28.4	29.2
75	------	23.8	------	25.6	24.3	25.7	24.7	25.8	24.8
100	------	20.6	------	------	22.7	23.5	22.5	22.3	22.3
125	------	------	------	------	------	------	------	20.9	20.7

	—896	—899	—901	—903	—906	—908	—910	—913	—915
0	29.3	29.1	28.9	28.9	28.8	28.7	29.9	29.2	29.1
25	29.2	28.0	28.6	27.8	26.6	28.9	28.9	28.2	29.0
50	26.6	25.1	24.2	25.8	25.9	27.3	26.4	27.4	27.3
75	23.5	21.6	21.9	20.9	23.6	24.7	23.0	25.9	25.3
100	21.0	19.8	19.5	18.6	19.6	20.1	21.0	24.6	22.5
125	19.3	------	------	------	17.8	------	19.4	------	------

	-917	—920	— 922	-- 924	— 927	-929
0	28.9	29.1	29.5	29.7	29.7	29.9
25	28.0	28.8	27.9	28.6	29.4	29.3
50	27.4	27.9	27.3	27.2	28.3	28.9
75	25.7	26.9	25.8	25.6	25.0	27.2
100	23.4	25.4	22.4	22.4	22.4	24.1
125	21.4	------	19.8	------	------	22.4

Where sharp inflections in the curve occurred above the first significant temperature gradient, they were disregarded if it was apparent that they were due not to a special feature of the water but to the unavoidable jagging of the instrument caused by the uneven tension of the BT wire at any one time.

Owing to the gradual transition between the isothermal layer and the thermocline as indicated by a number of the traces, the difficulty of ascertaining the depth of the isothermal layer necessitated the establishment of an arbitrary measure of temperature gradient. Thus for our purpose a gradient less than

1° F./25 feet (about 1° C./15 meters) did not constitute a thermocline. On this basis the total temperature drop within the isothermal layer did not exceed 2° C. in all cases. That depth below which the first significant gradient occurred was accepted as the depth of the isothermal layer. Layer depth values are entered in Table 2.

TABLE 2.—*Layer depth temperature*

Station No.	Layer depth		Station No.	Layer depth	
	C. meters			*C. meters*	
BT —820	29.0	36	—880	29.0	40
—822	28.9	49	—883	29.0	46
—824	29.2	52	—885	28.8	43
—826	29.0	49	—890	28.5	40
—829	29.4	49	—892	28.3	52
—833	29.9	47	—894	29.1	53
—836	29.6	55	—986	28.9	43
—843	29.3	38	—899	28.4	37
—846	29.0	34	—901	28.7	21
—848	29.4	45	—903	28.9	15
—850	29.0	47	—906	28.6	31
—855	28.9	38	—908	27.6	46
—861	29.8	43	—910	28.1	30
—863	29.5	51	—913	29.2	13
—865	29.3	52	—915	29.0	27
—867	27.7	55	—917	26.8	50
—869	28.8	54	—920		
—871	29.2	40	—922	26.7	64
—873	28.5	34	—924	29.0	57
—876	28.8	44	—927	28.5	55
—878	29.4	54	—929	28.6	57

STATION PLAN

Fig. 1 shows a layout of the carefully spaced network of BT and hydrographic stations occupied during the survey. Numerals represent station numbers. Where no BT station is shown between any two adjacent hydrographic stations occupied in succession, BT observations were taken when the boat stopped to make hydrographic measurements.

TEMPERATURES

The spacing of isotherms in the distribution chart for temperature at the surface was made at an interval of 0.2° C. as against 0.5° C. at 50 meters. This is to bring out by comparison the interesting feature shown by the strong horizontal temperature gradients at 50 meters over Stewart Bank located approximately in the western center of the 5° quadrangle west of northern Luzon.

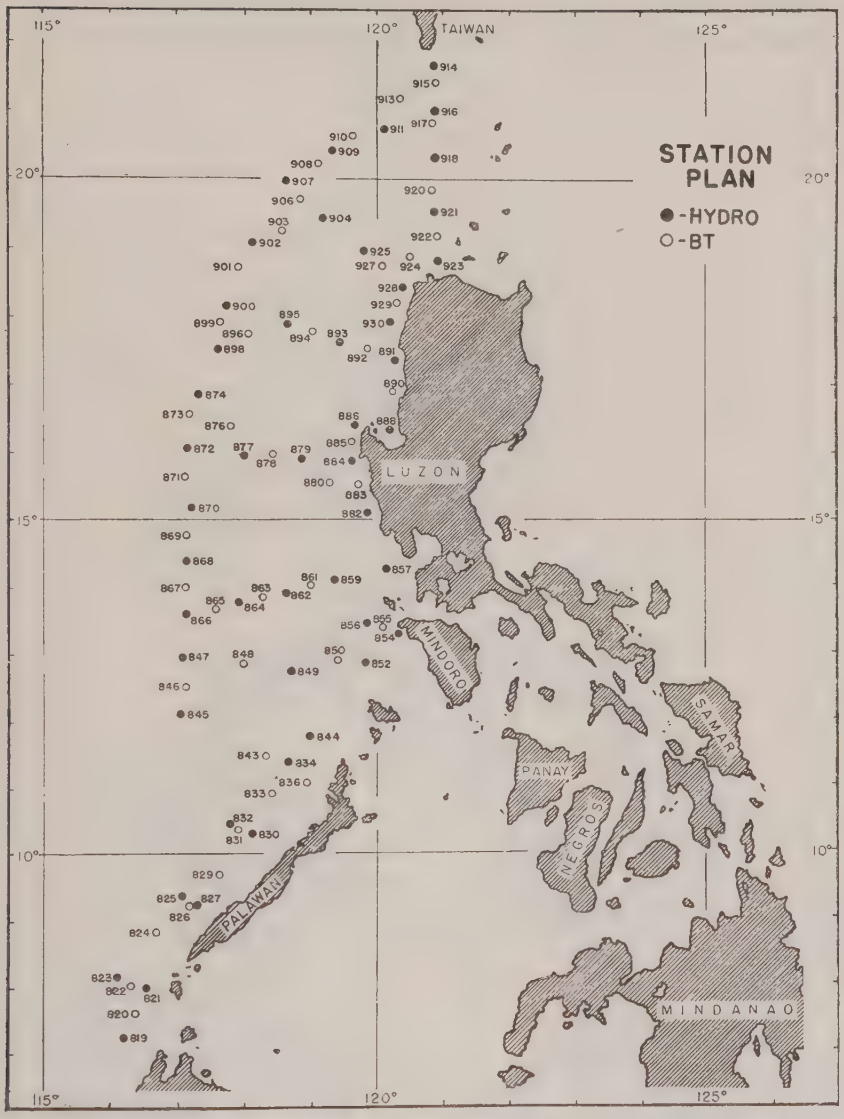


FIG. 1. Lay-out of stations occupied during the cruise of the *S. F. Baird*, July-August, 1949

Figs. 2 and 3 present the horizontal distributions of temperature at the surface and at a depth of 50 meters.

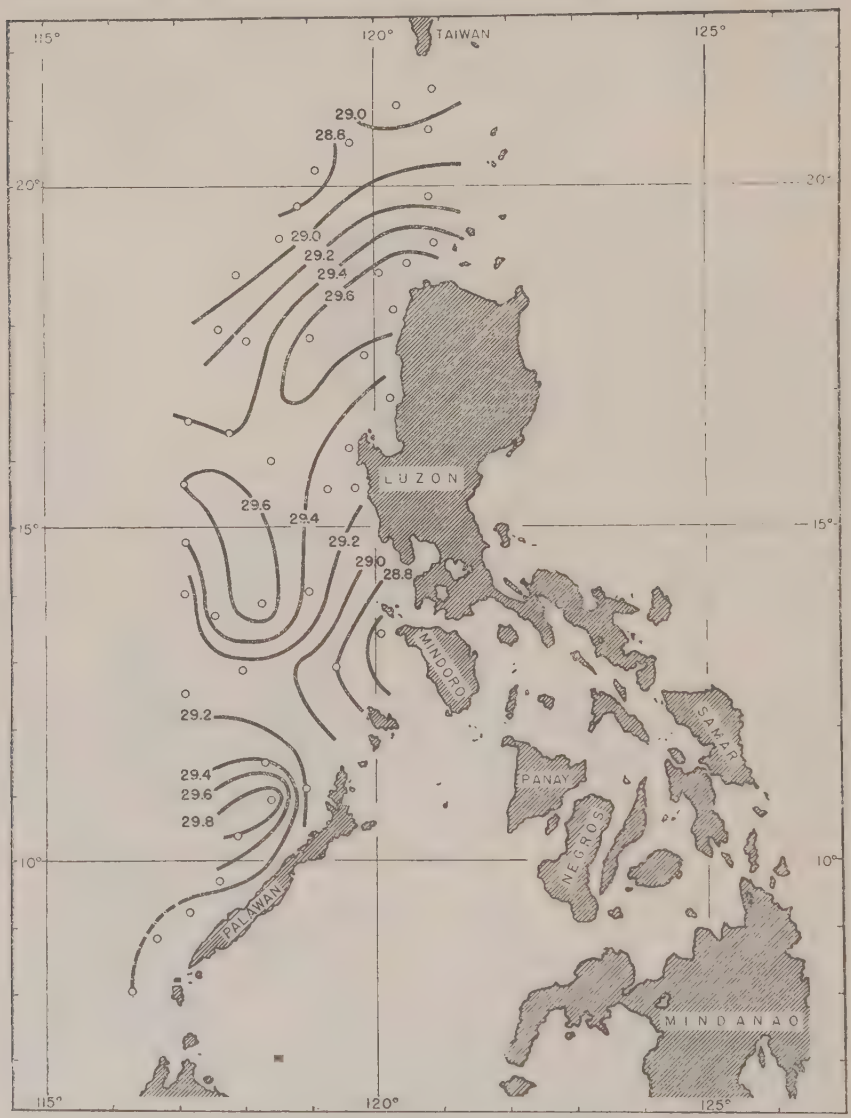


FIG. 2. Temperature distribution at the surface.

Surface.—Temperatures are generally lower in the northern than in the southern part of the area, the difference between the maximum and minimum values exceeding 1.0° C. In the southern part close to the shore the temperature increases from east to west but shows a reverse trend in the area to the north off northwestern Luzon.

Two patches of water having a temperature higher than 29.6° C. make up the warm region which appears west of

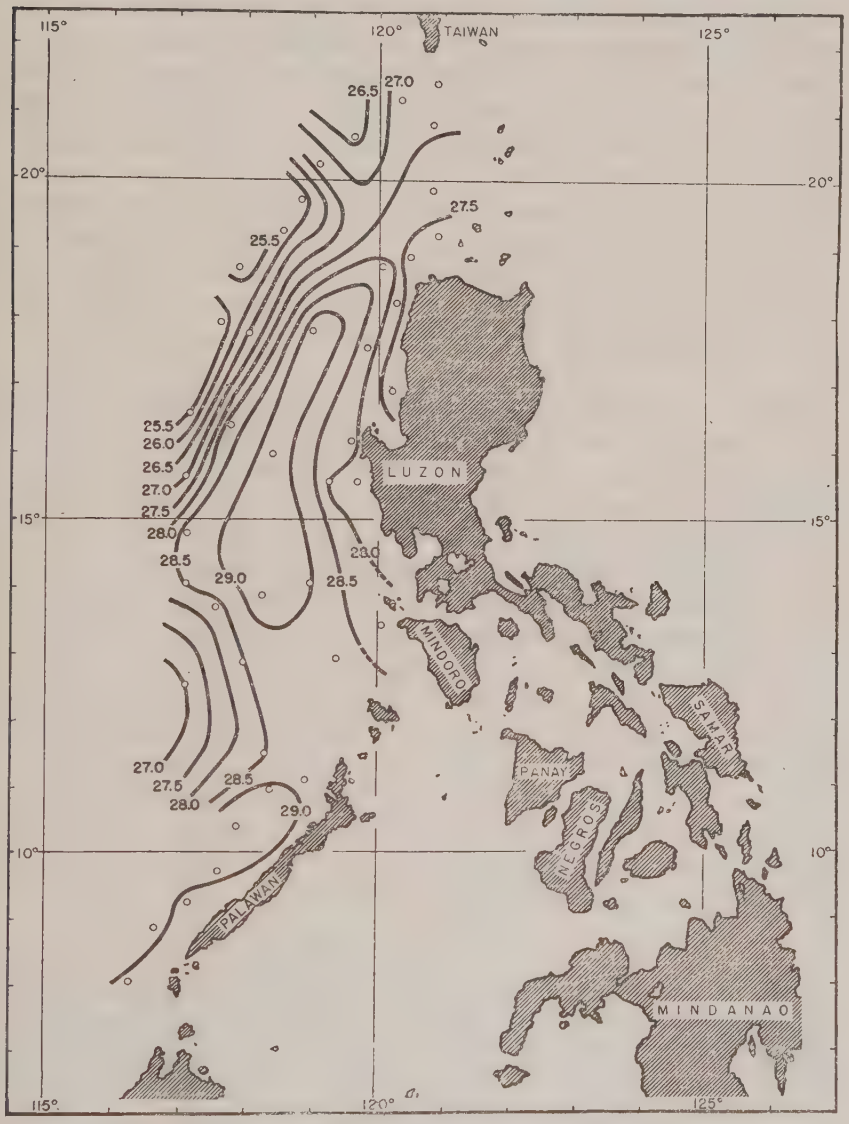


Fig. 3. Temperature distribution at 50 meters.

Luzon. This warm water has been found by Leipper and Wood (1947) to migrate from north to south during the northeast and in the opposite direction during the southwest monsoon period. Due to its large extent and its apparent displacement further south than when found by these investigators,

it seems likely that this warm water must have reached the limit of its southern migration at time of survey.

Another region of warm water much less in extent but of higher temperature appears off northwestern Palawan. Presumably this is a part of the South China Sea water that has broken away from the parent stream and found its way through the narrow trough separating Palawan from the extensive shallow reefs to the west. Upon hitting the shallow area at the northern tip of Palawan, the water departs from its normal course to form what appears to be a tight eddy. This pattern of flow based on the tonguelike distribution of temperature may not be confirmed by the actual streamlines owing to the wider fluctuations in salinity as shown by the hydrographic data.

Fifty meters.—At this depth the two warm patches found at the surface close to each other have coalesced to form a band of water tapering off to the northeast. Its broad base extends as far south as 13° 30′ N. latitude. The other end is seen to extend as far north as 18° N. latitude.

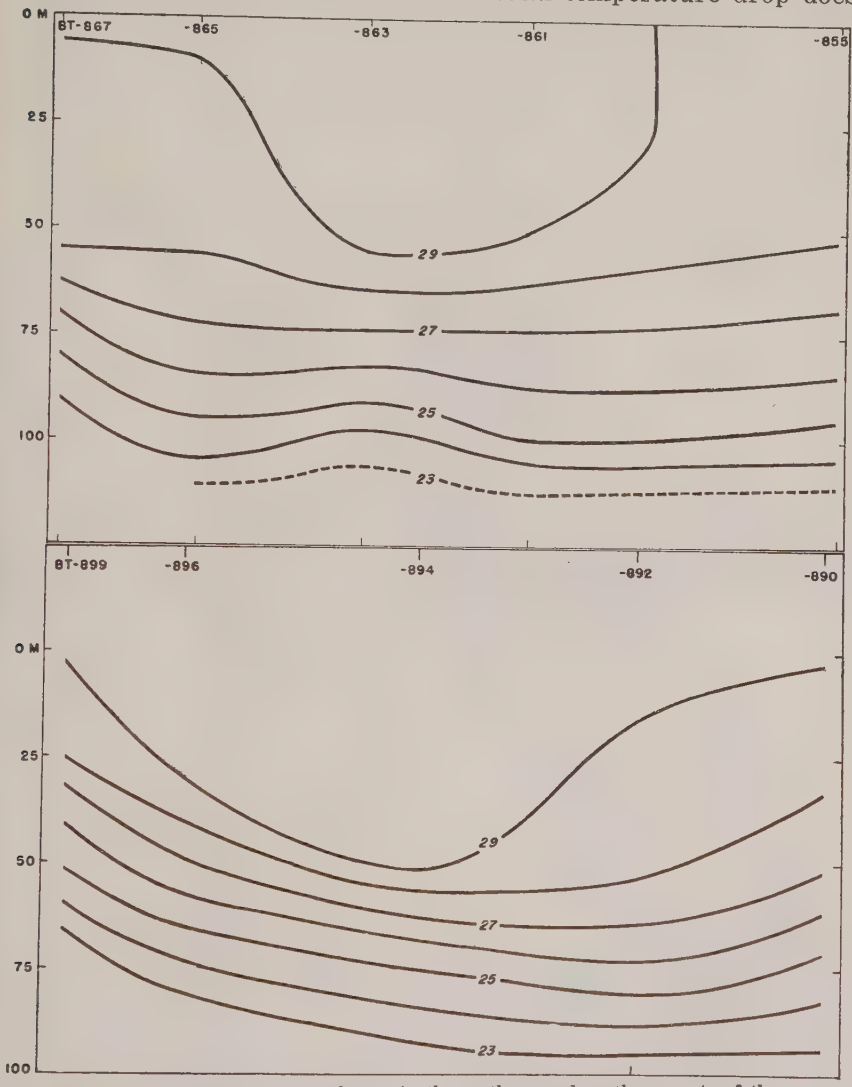
A special feature of the temperature distribution at this depth is the packing of the isotherms over and in the vicinity of Stewart Bank referred to previously. These marked horizontal temperature gradients reveal the possible presence of processes taking place that may account for the highly productive fisheries reported by fishermen in that area. That the presence of the cold water there is not a temporary feature is corroborated by the Japanese data collected during the same period in 1937.

Another noteworthy feature of the temperature distribution at this depth is the appearance of a tongue of warm water extending northeastward from the region of warm water.

ISOTHERMAL LAYER

Figs. 4, 5, and 6 are profiles presenting the extent of the isothermal layer. The first profile runs along the line of stations from BT–855 to BT–867 cutting across the base of the band of warm water enclosed by the 29°-isotherm shown in fig. 3. The second profile starts from BT–890 directly north of Lingayen Gulf and extends northwestward in the direction of Stewart Bank. The position of the profile in fig. 6 was chosen to conform with the apparent axial position of the 50-meter isobath, which is shown in fig. 7 to run from BT–822 west of Balabac Strait to BT–917 in the Bashi Channel south of Formosa.

These profiles show the 29°-isotherm to define the lateral and vertical boundaries of the isothermal layer everywhere except as shown in fig. 4. On either side of the isothermal layer shown in this figure, there is another layer of water of greater thickness within which the total temperature drop does



FIGS. 4 and 5. Profiles of isotherms in the southern and northern parts of the isothermal layer.

not deviate more than 1° from 28° C. This profile further shows lower temperatures at all depths than in the southern section of the central core of warm water. This may be due

to solar heat being rapidly dispersed downward by more active vertical circulation. The same process probably also explains the disappearance of the 29°-isotherm in the landward part of the section. That the mixing resulting from such circulation does not penetrate deeper than 50 meters is shown by the position of the 28°-isotherm which is only slightly displaced horizontally. The obliquity of the isotherms on both sides of the isothermal layer in the northern section indicates that the horizontally unstable water mass depicted in fig. 3 extends to greater depths.

The crowding of the isotherms on the southern part as shown in fig. 6 indicates the intensity of the thermal stratification

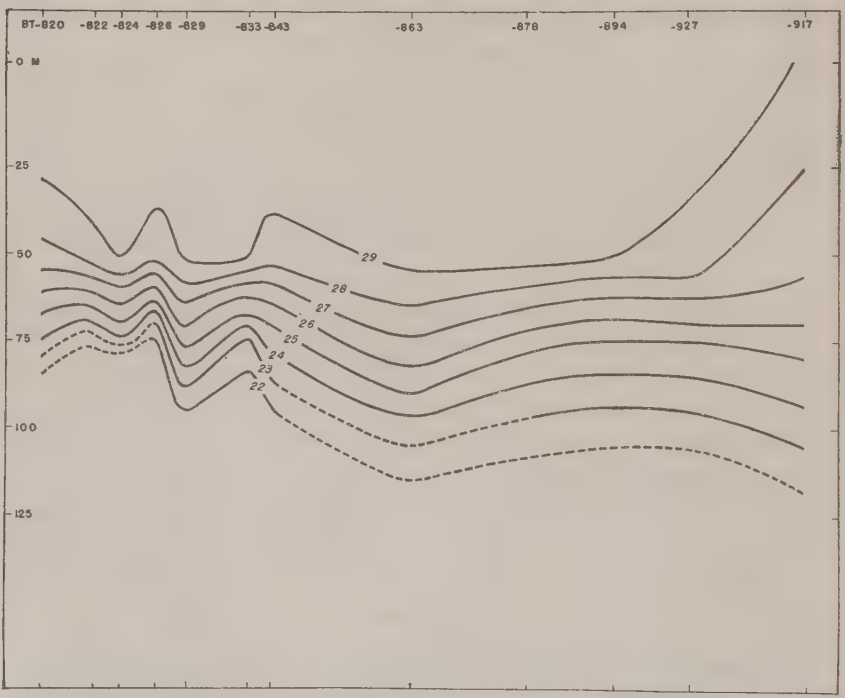


FIG. 6. Profile of isotherms in a longitudinal position near the center of the isothermal layer.

below the shallow isothermal layer there, while their sharp slopes probably represent the combined effects of the tight eddy referred to previously and the unusually rough seas encountered during the first days of the survey. The distortion of scale in representing horizontal and vertical distances in the profile exaggerates the slopes which will appear more gentle under actual sea conditions. Beyond the northern periphery of the small eddy the isotherms rise slowly at first and then slope

rapidly upward as the water reaches the passages north of Luzon.

The series of BT traces presented in fig. 8 show roughly the direction of movement of the isothermal layer and the rate of its transport. Degradation of the gradients follows the

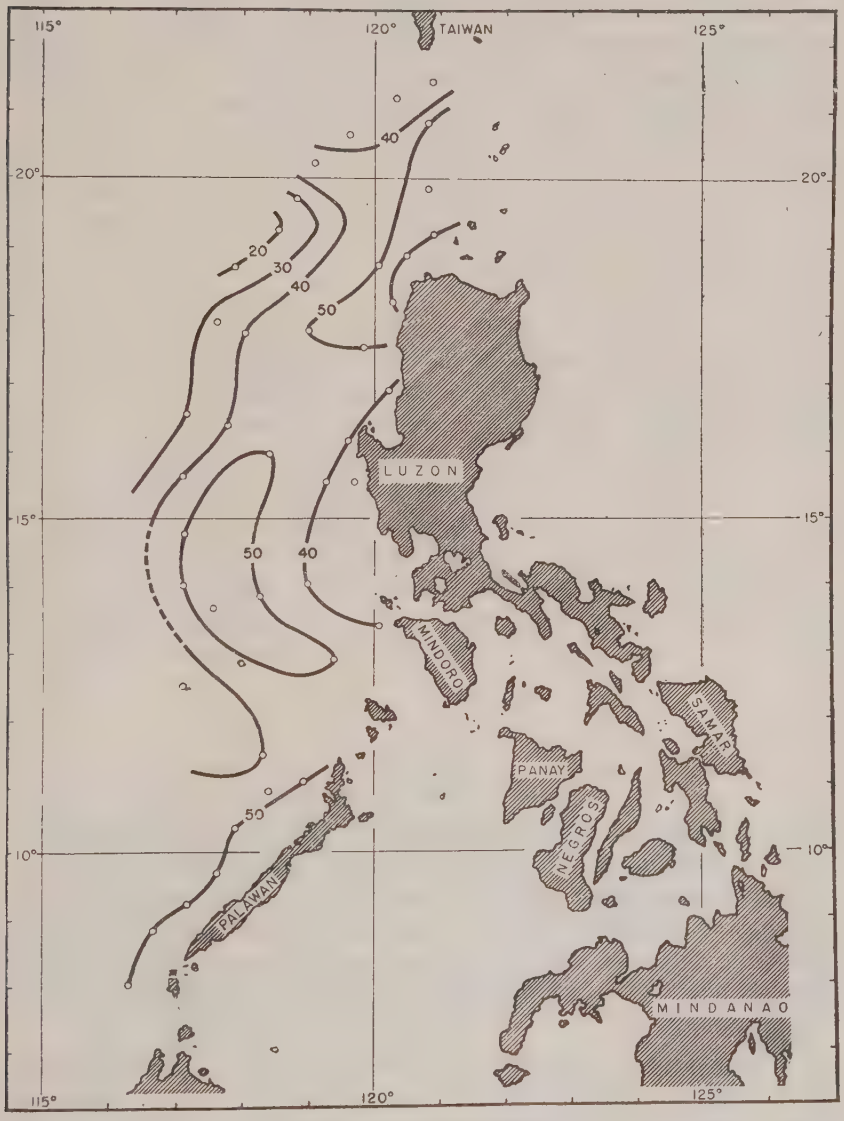


FIG. 7. Layer depth chart.

assumed line of flow. Based on the concept of maximum flow in the direction of maximum degradation, the rate of motion should be greatest toward the north in the direction of the axis of the isothermal layer.

CONCLUSIONS

The full understanding of the mechanism responsible for the transport of water deduced from the degradation of the traces in fig. 8 must await specialized studies. Whatever the mechanism, such transport probably will be destructive to the fishing grounds on the narrow insular shelf to the extent that the freely floating plant and animal life may be carried away from the coastal waters where they maintain the fisheries.

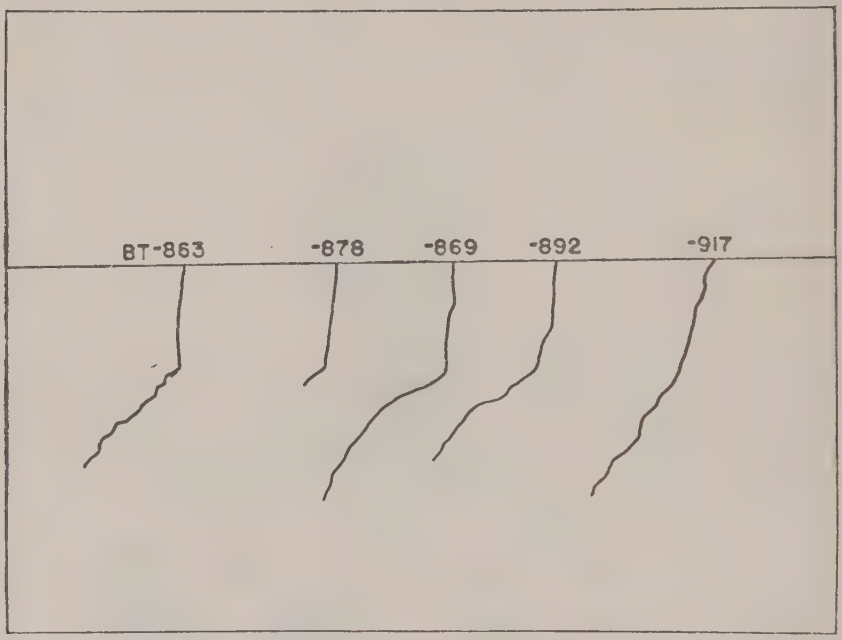


FIG. 8. Degradation of gradients.

The importance of this mechanism seems to have been recognized by the Japanese who investigated the other side of the isothermal layer near Stewart Bank. The promiscuity of distribution of the stations they occupied in that area apparently shows an attempt to analyze the agency responsible for the maintenance of the horizontally unstable water mass shown in figs. 2 and 3.

The banking of cold water against the edge of the isothermal layer near Stewart Bank and the presence of the tongue of warm water off northwestern Luzon (fig. 4) are special features of the temperature distribution that should be of value to tuna long-line operators. Japanese investigations show that such thermal features are indicative of routes of migration of the tuna.

What effects this thermal structure of the isothermal layer and the thermocline have on the biological processes can probably be deduced from a study of the distribution of the chemical and biological data also collected during the cruise. Such aspect was outside the scope of this report and, therefore, no attempt was made to analyze them. However, a few statements may be worthwhile to make at this time. If the temperature gradients within the thermocline are strong, lateral diffusion can be expected to be correspondingly great and if the isotherms sweep upward in a particular region, the return of the plant nutrients removed from the layer of plant activity can easily take place. Due to the persistence of the thermocline throughout the year in Philippine waters especially in offshore areas, the isopycnic transport of nutrients, which has been appreciated for some time, appears to be the only effective mechanism that brings up plant nutrients from below. For the purpose then of assessing the fertility of Philippine waters, stress should be given on the investigation of the large-scale horizontal circulation of our waters, the forces that maintain it, and the biological processes with which it is associated.

Admittedly, the thermal structure of the water presented in this report may represent only one stage in the cycle of oceanographic events. However, its investigation such as was attempted herein may provide a starting point in analyzing the secular changes in its character.

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ILLUSTRATIONS

TEXT FIGURES

FIG. 1. Layout of stations occupied during the cruise of the *S. F. Baird*, July–August, 1949.
2. Temperature distribution at the surface.
3. Temperature distribution at 50 meters.
FIGS. 4 and 5. Profiles of isotherms of the northern and southern parts of the isothermal layer.
6. Profile of isotherms in a longitudinal position near the center of the isothermal layer.
7. Layer depth chart.
8. Degradation of gradients.

OCEANOGRAPHY IN THE PHILIPPINES[1]

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Oceanography, as the study of the sea in all its aspects, is the meeting ground of various sciences that deal with the sea. In the special physical, chemical, and biological fields, oceanography is of very recent development in the Philippines. The first scientifically significant study of our waters was made in 1874 and 1875 by the globe-encircling *Challenger* expedition; the latest is that of the *Galathea* in 1951. Up to the intensive survey here of the *Spencer F. Baird* in 1947–49, only three foreign expeditions of similar nature (not including the Japanese-sponsored ones) have visited our shores, namely, the *Planet* in 1912, the *Dana* in 1929, and the *Snellius* in 1929–30. All others have only served in a general way to establish gross features of the ocean bottom and the general distribution of certain physical and chemical properties. Miguel Selga, S. J., former director of the Philippine Weather Bureau, has made a fine chronological compilation of these contributions to the oceanography of the Philippines, starting from Magellan's historic "first sounding" of the Pacific in 1521 up to the beginning of the present century.

Among the most noteworthy expeditions of the sixteenth century that made definite contributions to Philippine hydrographic knowledge, Selga mentions the *Nuestra Señora de Buena Experanza* (1587) which obtained astronomically determined positions for several places of the Islands, particularly the Pratas Shoal and the Babuyan Islands, and that of the *Desire* (1588) under Thomas Fuller, who made detailed observation of heights, soundings, latitudes and distances of certain places like Cape Espiritu Santo, Sibuyan Island, Panay, Negros, and Mindanao. In the seventeenth century Hernando de los Rios Coronel, inventor of the *astrolabe,* sent to Madrid from Manila a map he had drawn of Formosa Island, Luzon, and China, and wrote important sailing directions for the Manila–Nueva España (1605) and Acapulco–Manila (1611) routes.

[1] This paper was submitted as a contribution of the Philippine Delegation to the Third Meeting of the Indo-Pacific Fisheries Council at Madras, India, February, 1951; brought up to date as of August, 1951.

In 1662 a Dominican priest of Manila, Ignacio Muñoz, prepared a book on navigation as well as a series of hydrographic charts which was exaggerated as the best representation ever made at that time of all the oceans that have been navigated. Francisco Ignacio Alzina, S.J., after 30 years of missionary work in the Visayan Islands, left in 1668 a manuscript report containing, among various subjects, a detailed account of the tides and currents of the region. The outstanding expedition of the period was that of the *Cygnet* (1688) in southern Mindanao where William Dampier was the first to describe in the English language the havoc done on the bottoms of ships by the *teredo* of our coasts.

In the eighteenth century two officers, Francisco Diaz Romero and Antonio de Chandia, jointly published a Philippine map in 1727. In 1734 Pedro Murillo Velarde, S.J., published a hydrographic map of the Philippine Islands which became popular and which served for more than a century as the basis for subsequent maps by European geographers. This map showed the reef of rocks on the China Sea where the English ship *Scarborough* struck on September 12, 1748, fourteen years after its publication. This shoal has since been known as the Scarborough Shoal. In 1762 William Nicholson, master of the *Elizabeth* belonging to the British fleet that captured Manila, made a hydrographic map of Manila Bay and Cavite harbor that presented the configuration of the shore line with such exactness and the depths with such accuracy that it can still be used for vessels in entering the bay. The map also gives tidal data and bearings of the dangerous San Nicolas Shoal. In 1789 an expedition under Captain Alejandro Malaspina left Spain on a five-year scientific world cruise to collect botanical and zoological specimens and to study the navigation, meteorology, and hydrography of the various oceans. The corvettes *Atrevida* and *Descubierta* belonging to the expedition reached the Philippines early in 1792 and made astronomical, magnetic, meteorological, hydrographic and gravity observations at several places. Captain Jose Espinosa, one of the officers of the expedition who published an account of events therein, later became the Chief of the Hydrographic Service in the Philippines, upon the recommendation of Governor Aguilar of the Philippines in 1796 in connection with the formation of a Hydrographic Atlas on the occasion of the opening of the port of Manila to foreign ships and the occupation of the Singapore Straits by the British Navy.

At the beginning of the nineteenth century the ship *Santa Lucia* commanded by Riquelme surveyed the Scarborough Shoal, and the ship *Magallanes* did hydrographic work in the Bashi Channel. In 1808 William Dalrymple, navigator turned hydrographer, published several maps, charts, routes, sailing directions, and narratives of voyages over the Pacific. A French chart of the Basilan Strait was drawn by the French pilot Philibert on board the *Rhone* in 1819. In the same year, Mallat published a map of the Sulu Archipelago and a book dealing with Philippine hydrography. The United States Exploring Expedition under Captain Charles Wilkes visited the Philippines in 1841 and 1842 and made some observations on meteorology and hydrography. In 1843 the British ship *Samarang* under Captain Edward Belcher reconnoitered Philippine seas, made several magnetic observations at Manila, Cavite, and Zamboanga, and determined astronomical latitudes and longitudes and magnetic variation and dip at several places. From 1850 to 1873 three English expeditions visited Philippine shores. The *Royalist* under Bate surveyed the western coast of Palawan and adjacent reefs (1850–54), the *Rifflemann* under Reed surveyed the Balabac Strait (1868–69), and the *Nassau* under Chimmo reconnoitered the eastern coast of Palawan and surveyed part of the Sulu Archipelago, obtaining some values of temperature of the deep waters.

In 1874 and 1875 the famous British *Challenger* expedition, perhaps the most comprehensive exploration of the sea in its physical and biological aspects that has ever been attempted by any single agency, called at several Philippine ports during its circumnavigation of the world (1872–76). Special investigations of chemical, physical, and biological conditions were conducted. Soundings and temperature observations were made in the Sulu Sea and deposits were trawled from the bottom in the Visayan region. In addition, magnetic, meteorological and astronomical observations were attempted. In 1879 the *Derrotero del Archipelago Filipino* or the Coast Pilot, based upon the hydrographic survey of Montero, the investigations of Spanish naval officers, the British survey of the Balabac Strait, Palawan and Jolo, and the survey of the island of Isabela de Basilan by the French navy, was published by Camilo de Arana. The work referred mainly to tides and tidal streams, depths, water temperatures, and variations of the compass. In 1881 the United States undertook two important hydro-

graphic investigations related to the oceanography of Philippine waters. The first was for the preparation of new large scale charts of the China Sea; the second, for the accurate and modern redetermination of the latitude and longitude of points to which capes, islets, towns, and lighthouses had been previously referred. The gunboat U. S. S. *Palos* transported the officers and instruments from port to port.

At the turn of the century, from 1907 to 1909, the U. S. Fisheries steamer *Albatross* was actively engaged in securing hydrographic, dredging, and physical records of almost all the seas of the Philippine Islands and adjacent waters. In 1907 the German survey vessel *Planet* made 36 depth determinations from southeast Mindanao to the eastern coast of central Luzon and by a network of soundings in four cross-sections discovered a trough which proved to be the deepest bottom of any ocean in the world, from 8,000 to 9,000 meters in depth. Later, in 1912 the same vessel sounded 32,078 feet about 40 miles off the north coast of Mindanao. In 1927 another German vessel, the cruiser *Emden,* explored the same region using echo-sounding apparatus and correcting for temperature, salinity, and pressure conditions. It made several hundred soundings 46 of which exceeded 10,000 meters, and recorded the deepest part of the world, 10,793 meters or 35,410 feet, 40 miles east of Northern Mindanao. In 1929 the Danish steam vessel, the R. S. S. *Dana,* on an oceanographic voyage around the world stopped at the Philippines and made observations of temperature, salinity, and oxygen content in the south China Sea and in the Sulu Sea. In 1930 the 1,055-ton Dutch steam vessel, H. M. S. *Willebrord Snellius,* while engaged in oceanographic research in the seas of the East Indies, visited the Western Pacific and made several soundings of the Philippine Deep. Records are available of Japanese oceanographic investigations made in and around Philippine waters from 1934 to 1943, involving several observations of temperature, salinity, oxygen, nutrient salts, and pH up to about 1000 meters. It is worthy of note that earlier surveying ships of the Imperial Japanese Navy, particularly the *Manshu,* the *Yamato,* and the *Musashi,* engaged for several years in biological and hydrographic investigations of the southwestern sector of the North Pacific Ocean, and that bottom deposits of the Philippine area are contained in the map prepared of these reports by Hanzawa of the University of Sendai. Various cutters of the U. S. Coast and

Geodetic Survey operated in Philippine waters before the Pacific War, charting our coast and doing various other hydrographic work. Prominent among these were the *Marinduque*, the *Fathometer*, and the *Pathfinder*. The work has been taken over by the various survey ships of the Philippine Bureau of Coast and Geodetic Survey.

In July and August of 1951 the *Galathea*, a 1,630-ton Danish Navy corvette, on a two-year round-the-world deep-sea research expedition (1950–52), made intensive studies of the Philippine Deep. The survey was chiefly biological in nature, although hydrographic and magnetic work was also attempted. Bottom sediments and samples of marine life at the immense depths were hauled to the surface. This is the first time scientific studies with modern methods and equipment have probed down to 35,000 feet below the sea. Among the many scientists on board under Dr. Anton Bruun during its stay in Philippine waters were three Filipino specialists from the Philippine Bureau of Fisheries.

Prior to 1947 no single office in the Philippines was directly responsible for the collection and compilation of physical, chemical, and biological oceanographic data. The Philippine Weather Bureau, through its marine meteorology section, still collects and compiles sea temperature data from reports of commercial vessels, but reports are wholly confined to observations of surface values. This is more or less a continuation of the work done in 1920–31 when Selga compiled about 4,000 observations of sea surface temperatures in the Philippines, collected from the log-books of ocean-going, commercial steamships, U. S. Army-Navy transports, interisland vessels, and cutters of the U. S. Coast and Geodetic Survey. The Philippine Bureau of Coast and Geodetic Survey, which is charged with the duty of surveying the coasts of our Archipelago, sounding its oceans, and charting its bays, also collects at its tidal stations sea water samples and analyses them for salinity, but observations are also limited to the surface waters. At present the Bureau of Fisheries is the only entity of the Philippine Government amply equipped in materials and men for the physical, chemical, and biological study of our seas.

Early in 1947, under the terms of the Philippine Rehabilitation Act of 1946, the U. S. Fish and Wildlife Service, through its Philippine Fishery Program, began an oceanographic investigation of Philippine waters that is said to be the most inten-

sive survey ever attempted in the history of the science. In two years its exploratory fishing and research ship, the *Spencer F. Baird,* a converted diesel electric tug of 800 tons gross with two 950 horsepower engines, explored an area of 810,000 square miles of Philippine seas, occupying no less than 526 oceanographic stations averaging 1,500 meters in depth, some going as deep as 2,000 meters. Serial observations were made of temperature, salinity, oxygen, phosphates, silicates, nitrates, nitrites, pH and alkalinity, and the enormous amount of data collected are now being reduced and interpreted by the U. S. Fish and Wildlife Service. When the Philippine Fishery Program closed its office in 1950 it left with the Philippine Bureau of Fisheries, among various items, a compact set of oceanographic gear, equipment and supplies, as well as the research and exploratory vessel, the *David Starr Jordan.* Realizing the importance of continuing the work started by the U. S. Fish and Wildlife Service, the Bureau of Fisheries has set up a hydrology section within its division of fish culture and fisheries biology. Technical men trained in oceanography by the U. S. Fish and Wildlife Service in its offices in the Philippines and in the United States have been detailed to this section. The *David Starr Jordan,* a 50-foot, 125-horsepower diesel type vessel, has been rigged and equipped for oceanographic work, and since February of 1951 it has been exclusively used for periodic monthly oceanographic surveys of Manila Bay. The hydrology section has also begun piecewise surveys of important fishing grounds, like Malampaya Sound and the Visayan Shelf. It is deemed that its oceanographic studies will help solve some of the vital problems of Philippine fisheries. Its wealth of collected data alone will be a definite contribution to oceanographic knowledge.

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THE RATE OF ALGÆ (LUMUT) PRODUCTION IN THE DAGAT-DAGATAN SALT-WATER FISHERY EXPERIMENTAL STATION FISHPONDS.[1]

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FIVE TEXT FIGURES

SUMMARY

Lumut is the Tagalog term used to designate the assemblage of filamentous green algæ (Chlorophyceæ) sometimes intermingled with filamentous blue-green algæ (Myxophyceæ) growing in brackish and salt-water ponds and composing the main bulk of the natural food of cultivated bañgos, or milkfish, *Chanos chanos* (Forskål).

The present experiment is intended to provide the basic rate of production data that may eventually be used as a standard of estimate of productivity in bañgos fishpond projects. It was undertaken at the Dagat-dagatan Salt-Water Fishery Experimental Station, Malabon–Navotas, Rizal, in six equally-sized ponds lying side by side, for a period of eight months and divided into two experimental runs of four months duration.

"Lumut" is a vernacular term (Tagalog) used for the assemblage of filamentous green algæ (Class Chlorophyceæ) and sometimes intermingled with some of the filamentous blue-green algæ (Class Myxophyceæ) which grow in brackish and salt-water ponds in the Philippines. It composes the main bulk of the food of *bañgos,* or milkfish, *Chanos chanos* (Forskål) under cultivation.

The following experiment on lumut is intended to provide a method of estimating the total production of the algæ per unit area under conditions obtaining in Philippine milkfish ponds. This should provide a basis in estimating the bañgos productivity in fishpond projects. Experimental work was undertaken from November 1, 1949 to February 27, 1950 and from July 31, 1950 to October 30, 1950 at the Dagat-dagatan Salt-Water Fishery Experimental Station, Malabon–Navotas, Rizal Province, Luzon.

[1] This investigation was made possible through funds provided by the Philippine Fishery Program of the U. S. Fish and Wildlife Service, and upon suggestion of Mr. Herbert E. Warfel, Chief, Biological and Oceanographic investigations of the Program. Sincere thanks are expressed by the writers for the valuable help rendered by Mr. Warfel and the Program he represents, without whose aid this project may not have been carried through to a successful completion.

MATERIALS AND METHODS

Six ponds of nearly identical construction, each 50 square meters in area (5 × 10 meters), and located side by side were selected for the experiment. The ponds were drained, leveled, then dried. With the gates properly screened, a limited amount of water was allowed into the ponds. Lumut growth was started in each pond by planting on the pond bottom six patches of weighed algæ of about same age stage obtained from one spot of another pond of the station.

Microscopic examination of the algæ used showed that they were predominantly composed of *Chaetomorpha* sp. with few stray filaments of *Enteromorpha intestinalis* and *Cladophora* sp. and rarely some closely adhering filamentous blue-green algæ.

Observations on temperature, pH, salinity, depth of pond water and general weather conditions were made two days each week (Tuesdays and Fridays). Two observations, one in the morning at 9:00 o'clock and the other in the afternoon at 3:00 o'clock, during these two days were made from the beginning until the end of the experiment.

These two experimental runs extended for a period of four months each, one for the high-salinity dry period (November to February) and the other for the low-salinity rainy period (July to October). The depth of the water was regulated during each period by not allowing the ponds to dry up nor go beyond a depth of one meter in order to minimize interference with the normal growth of the lumut. Renewal of the water in each of the experimental ponds was made once a week, the time for this procedure depending on the condition of the tide.

The observations on the rate of lumut growth in these six ponds were divided into three groups as follows:

GROUP A. *Ponds I and II.*—All the lumut planted in these two ponds was collected and weighed after every seven days. This lumut was returned to the same pond from where it was taken. The above procedure and other pertinent observations (meteorological and hydrographic observations) were undertaken in these two ponds during the entire span of the experiment.

GROUP B. *Ponds III and V.*—The lumut planted in these two ponds was collected and weighed after every 28 days. It was returned to the same pond and properly oriented to the condition very close to its state previous to weighing. This procedure and other pertinent observations

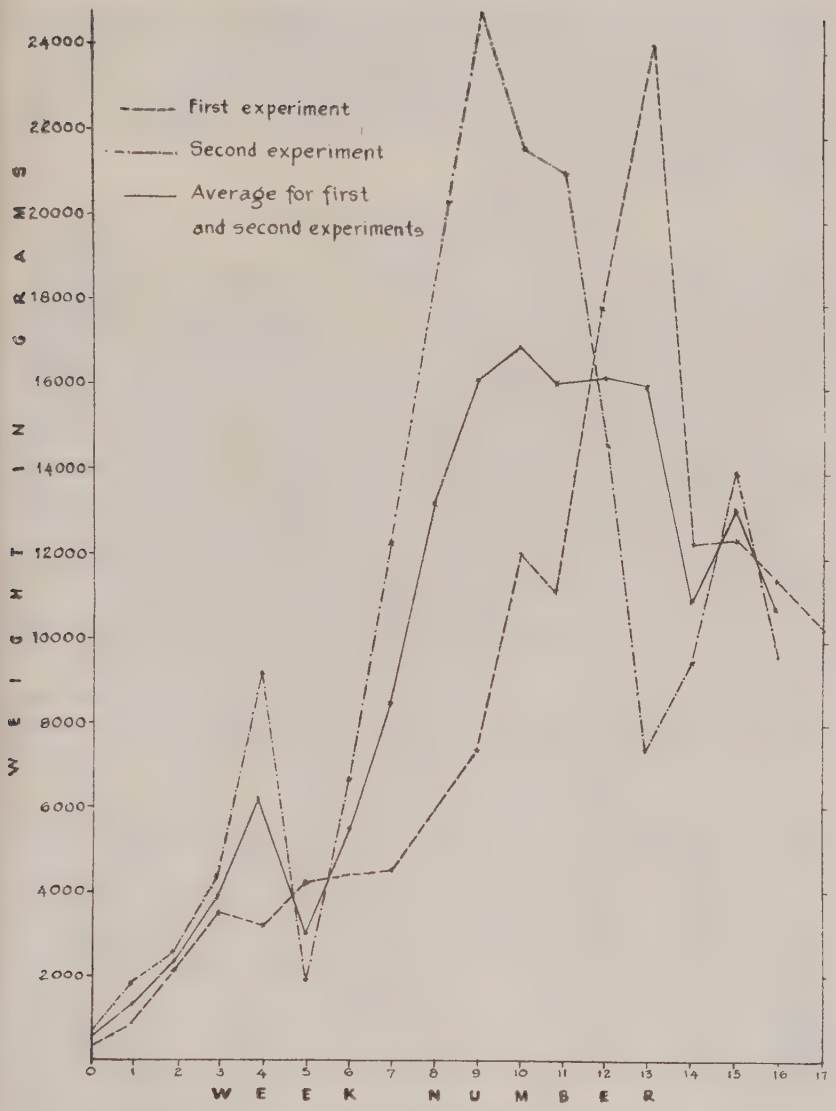

FIG. 1. Weekly increase in weight of lumut in experimental ponds I and II.

were undertaken in these two ponds during the entire span of the experiment.

GROUP C. *Ponds IV and VI.*—The lumut planted in these two ponds was collected and weighed at the end of the experimental period. Except for the above procedure the same observations as in groups A and B were made on these two ponds during the experiment.

The evaluation of the entire crop of lumut produced from each of these ponds at the end of the experiment is interpreted in terms of wet weight; that is, the weight taken as soon as water stops dripping from the algæ that have previously been hung on a line in the shade.

RESULTS AND DISCUSSION

Ponds I and II.—Tables 1 to 3 and fig. 1 show the trend of algal growth in these two ponds which was sampled weekly. Except for slight fluctuations, the rate of growth of lumut in these two ponds was very rapid during the first few weeks. In the first experiment the rapid rise begins at the start of the experiment until the thirteenth week while in the second the rapid rise lasted only up to the ninth. After a maximum growth is attained there seems to be a decline in the amount of lumut. The weekly sampling showed in some cases very wide fluctuations showing either sharp increases or decreases. This may be due to sudden environmental changes such as sudden rainfall or sudden salinity change of the water. It may also be due to the frequency of handling, these two ponds having been subjected to weekly weighing of lumut. It seems that the maximum growth attainable is better in the second experiment or during the low salinity rainy period.

TABLE 1.—*Weekly increase in weight of lumut in Experimental Ponds I and II*

[First experiment—November 1, 1949 to February 27, 1950]

Date	Duration of culture (weeks)	Weight of lumut (gm.)	Growth from initial stock	
			Weight (gm.)	Per cent
1-XI-49	Initial stock	494.2		
7-XI-49	1	914.4	420.2	85.0
14-XI-49	2	2,113.2	1,619.0	327.6
21-XI-49	3	3,586.4	3,092.2	625.7
28-XI-49	4	3,206.5	2,712.3	548.8
5-XII-49	5	4,217.3	3,723.1	753.4
12-XII-49	6	4,430.3	3,936.1	796.5
19-XII-49	7	4,548.7	4,054.5	820.4
26-XII-49	8	5,924.7	5,430.5	1,098.9
4-I-50	9	7,300.7	6,806.5	1,377.3
10-I-50	10	12,247.0	11,752.8	2,378.5
16-I-50	11	10,810.8	10,316.6	2,087.5
23-I-50	12	11,704.0	17,209.8	3,482.4
30-I-50	13	24,579.1	24,084.9	4,873.5
6-II-50	14	12,229.1	11,734.9	2,374.5
13-II-50	15	12,417.3	11,923.1	2,412.6
20-II-50	16	11,453.4	10,959.2	2,217.6
27-II-50	17	10,489.5	9,995.3	2,022.5

TABLE 2.—*Weekly increase in weight of lumut in Experimental Ponds I and II*

[Second experiment—July 10, 1950 to October 30, 1950]

Date	Duration of culture (weeks)	Weight of lumut (gm.)	Growth from initial stock	
			Weight (gm.)	Per cent
7-VII-50	Initial stock	776.0		
14-VII-50	1	1,895.6	1,119.6	144.3
21-VII-50	2	2,565.7	1,789.7	230.6
28-VII-50	3	4,365.9	3,589.9	462.6
4-VIII-50	4	9,213.7	8,437.7	1,087.3
11-VIII-50	5	1,871.1	1,095.1	141.1
18-VIII-50	6	6,690.6	5,914.6	762.2
25-VIII-50	7	12,275.5	11,499.5	1,481.9
1-IX-50	8	20,440.5	19,664.5	2,534.1
8-IX-50	9	25,061.3	24,285.3	3,129.5
15-IX-50	10	21,553.0	20,777.0	2,677.5
22-IX-50	11	21,092.4	20,316.4	2,618.1
29-IX-50	12	14,628.3	13,852.3	1,785.1
6-IX-50	13	7,300.1	6,524.1	,840.7
13-X-50	14	9,475.6	8,699.6	1,121.1
20-X-50	15	14,017.0	13,241.0	1,706.3
30-X-50	16	9,752.4	8,976.4	1,156.8

TABLE 3.—*Average weekly increase in weight of lumut in Experimental Ponds I and II*

[First and second experiments]

Duration of culture	Weight of lumut (gm.)	Growth from initial stock	
		Weight (gm.)	Per cent
Initial stock	635.1		
1	1,405.0	769.9	121.2
2	2,339.4	1,704.3	268.4
3	3,976.1	3,341.0	326.1
4	6,210.1	5,575.0	877.8
5	3,044.2	2,409.1	379.3
6	5,560.4	4,925.3	775.5
7	8,412.1	7,777.0	1,224.5
8	13,182.5	12,547.4	1,975.7
9	16,181.0	15,545.9	2,447.8
10	16,900.0	16,264.9	2,560.1
11	15,951.6	15,316.5	2,411.7
12	16,166.2	15,531.1	2,445.5
13	15,939.6	15,304.5	2,409.8
14	10,852.3	10,217.2	1,608.8
15	13,217.6	12,582.5	1,981.2
16	10,602.9	9,967.8	1,569.5
17	5,244.7	4,609.6	725.8

Ponds III and V.—Tables 4 to 6 and fig. 2 show the monthly growth in these two ponds. As in ponds I and II the rate of growth of lumut in these two ponds showed very rapid rise from the beginning of the culture period to the second month. There may be increases during the third and fourth month but these may be very gradual and even actual decreases may be registered showing a tendency to level off after attaining a

peak. Again the second experimental period of the low salinity rainy period showed higher maximum growth of lumut. Actually the highest growth of lumut for all the ponds during

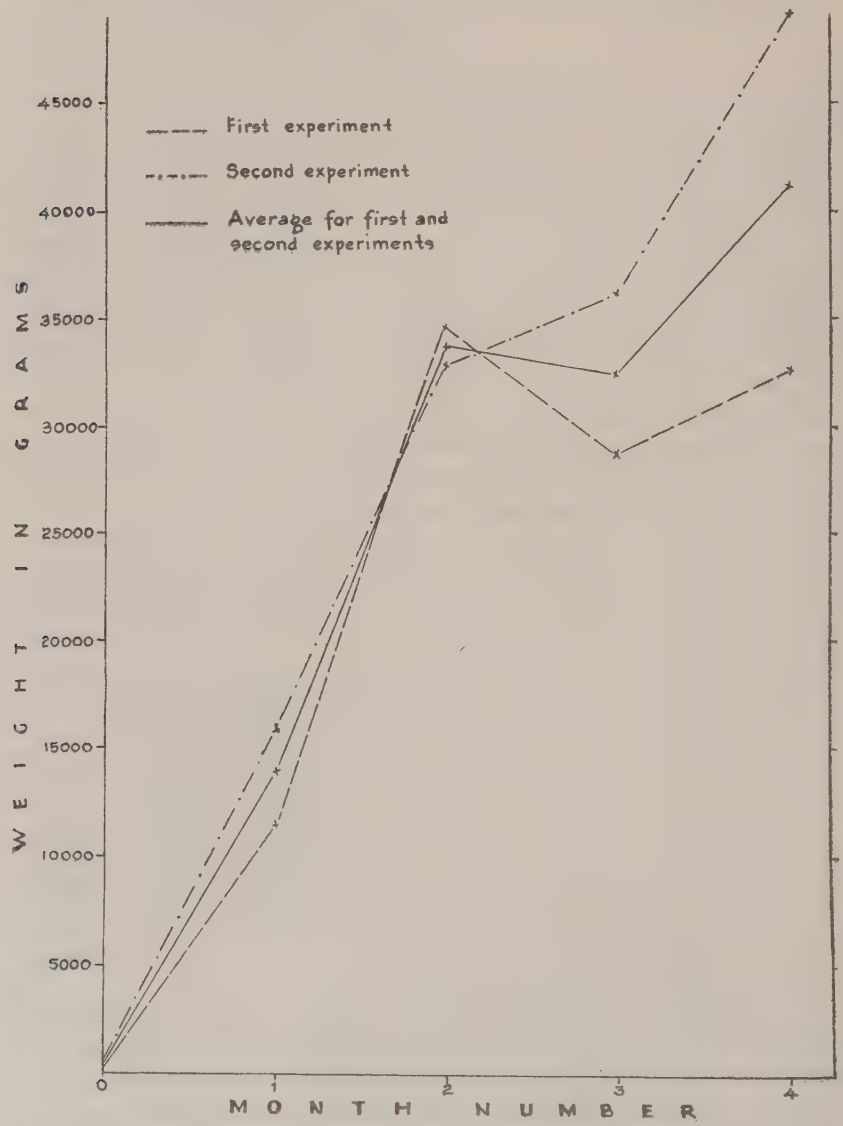

Fig. 2. Monthly increase in weight of lumut in experimental ponds III and V.

this experiment was obtained in this series with an amount of 54,658.8 grams in one pond (Pond III, 4th month) or 1,093.2 grams per square meter.

TABLE 4.—*Monthly increase in weight of lumut in Experimental Ponds III and V*

[First experiment—November 1, 1949 to February 27, 1950]

Duration of culture (months)	Weight of lumut (gm.)	Growth from initial stock	
		Weight (gm.)	Per cent
Initial stock	353.0		
1	11,731 5	11,378.5	3,223.4
2	35,182.5	34,829.5	9,866.7
3	29,033.6	28,680.6	8,164.8
4	33,055.8	32,702.8	9,264.2

TABLE 5.—*Monthly increase in weight of lumut in Experimental Ponds III and V*

[Second experiment—July 10, 1950 to October 30, 1950]

Duration of culture (months)	Weight of lumut (gm.)	Growth from initial stock	
		Weight (gm.)	Per cent
Initial stock	611.6		
1	16,329.6	15,718.0	2,561.0
2	33,311.2	32,699.6	5,346.6
3	36,798.2	36,186.6	5,916.7
4	50.689.8	50,078.2	8,188.1

TABLE 6.—*Average monthly increase in weight of lumut in Experimental Ponds III and V*

[First and second experiments]

Duration of culture months	Weight of lumut (gm.)	Growth from initial stock	
		Weight (gm.)	Per cent
Initial stock	482.3		
1	14,030.5	13,548.2	2,809.1
2	34,246.8	33,764.5	7,000.7
3	32,915.9	32,433.6	6,724.8
4	41,872.8	41,390.5	8,581.9

Ponds IV and VI.—Sampling at the end of the experiment period—4 months (Table 7 and fig. 3). After planting the initial stock of lumut these two ponds were left untouched except at the end of the experiment when the algæ were weighed to verify whether frequent handling may have something to do with their growth. The results indicate that frequent handling has no effect as shown by the fact that the rate of growth of the algæ in these ponds did not differ significantly

with those where the lumut is weighed weekly and monthly. The growth of algæ in these untouched ponds may have fluc-

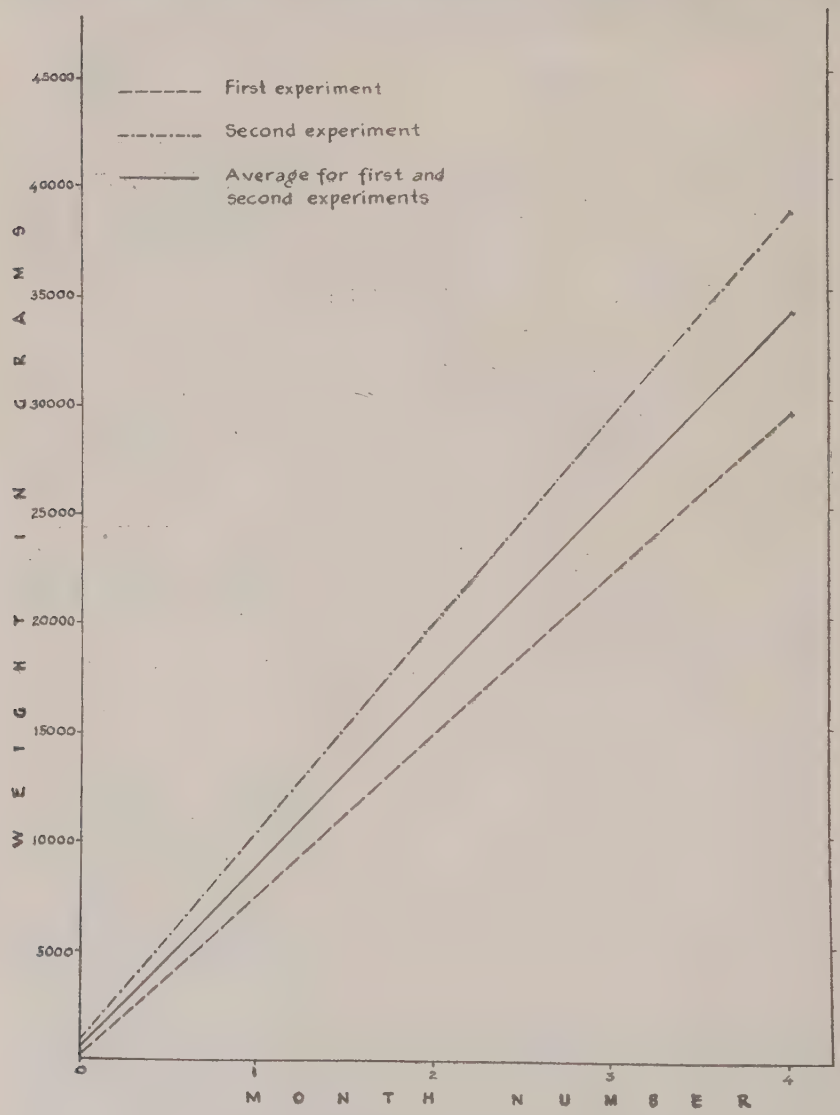

FIG. 3. Increase in weight of lumut in experimental ponds IV and VI at the end of experimental period.

tuated during the period in a similar manner as the two cases mentioned above.

TABLE 7.—*Increase in weight of lumut in Experimental Ponds IV and VI determined at the end of experimental period (four months)*

Experiment Number	Duration of culture	Weight of lumut (gm.)	Growth	
			Weight (gm.)	Per cent
First	Initial stock	384.0		
	4 months	29,895.0	29,511.0	7,685.2
Second	Initial stock	677.7		
	4 months	39,236.4	38,558.7	5,689.6
Average for first and second	Initial stock	530.8		
	4 months	34,565.7	34,034.9	6,412.0

The general meteorological and hydrographic observations (Tables 8 and 9, and fig. 4).—Considering that bangos ponds are brackish, the salinity remained at comparatively high level during the period of the first experiment—the lowest recorded being 20.6°/₀₀ and the highest 34.2°/₀₀ with an approximate average of 29.9°/₀₀. During the second experiment the salinity was comparatively much lower, ranging from 9.0°/₀₀ to 22.2°/₀₀ with an approximate average of 14.9°/₀₀. These fluctuations

TABLE 8.—*Average meteorological and hydrographic observations for Experimental Ponds I to VI*

[First experiment—November 1, 1949 to March 3, 1950]

Period (weeks)	Salinity °/₀₀	Rainfall (mm.)	Depth of pond water (cm.)	pH	Remarks
First	28.0	49.0	10.7	7.8	Water newly freshened, turbid; weather clear to passing shower.
Second	21.7	61.9	13.2	8.4	Lumut planted growing; water slightly turbid, deep; weather overcast to passing shower.
Third	27.8	8.3	10.9	8.2	Water turbid, deep; weather clear to passing shower.
Fourth	30.3	0	8.6	8.3	Good growth of algae; water turbid, low; weather generally fair.
Fifth	31.3	130.1	8.6	8.1	Water newly drained, turbid, low; weather clear to changeable,
Sixth	29.6	19.4	13.9	8.1	Water newly freshened, slightly turbid deep; weather cloudy to clear.
Seventh	23.5	0	8.9	7.7	Good growth of algae; water turbid, low; weather stormy.
Eighth	29.5	0	9.5	8.3	Water very slightly turbid, low; weather generally fair.
Ninth	27.9	21.4	6.0	8.2	Letting out water, turbid, low; weather clear to passing shower.
Tenth	29.8	11.2	11.5	8.2	Water newly freshened, turbid; weather generally fair.
Eleventh	31.2	3.8	9.5	8.0	Pond with a good growth of algae; water turbid, deep; fair weather.
Twelfth	31.7	2.3	18.6	8.2	Water slightly turbid, deep; weather generally fair.
Thirteenth	33.2	23.8	7.5	7.7	Letting out water, very turbid, low; weather clear to cloudy.
Fourteenth	31.5	0	14.9	8.0	Water newly freshened, turbid, deep; weather clear, gentle wind.
Fifteenth	32.3	0	11.6	8.3	About 80% of the pond area is covered with algae; water turbid; weather clear.
Sixteenth	33.5	4.1	12.2	7.8	Water turbid, deep; fair and very calm weather.
Seventeenth	33.3	0.3	10.3	7.5	Water turbid, low; weather clear to passing shower.
Eighteenth	33.8	0	18.4	-----	Pond newly freshened; water turbid, deep; weather generally fair.

TABLE 9.—*Average meteorological and hydrographic observations for Experimental Ponds I to VI*

[Secondary experiment—July 10, 1950 to October 30, 1950]

Period (Weeks)	Salinity °/oo	Rainfall (mm.)	Depth of fond water (cm.)	pH	Remarks
First	22.2	85.2	15.1	7.8	Pond newly planted with 6 patches of algae; water turbid, deep; weather cloudy with showers.
Second	15.2	213.5	25.0	7.7	Water newly freshened, turbid, deep; weather very stormy.
Third	12.6	100.6	38.3	7.2	Algae growing; water turbid, deep; weather very stormy.
Fourth	12.9	135.2	36.4	7.6	Water very turbid, deep; weather clear to passing showers.
Fifth	9.0	118.9	37.1	7.2	Do.
Sixth	10.1	24.4	23.8	8.0	Pond was drained; water very turbid, deep weather calm; partly cloudy.
Seventh	9.7	18.6	22.4	8.1	About 75% of the pond area is covered with algae; water turbid, deep; weather fair.
Eighth	15.3	27.9	21.5	7.9	Pond with a good growth of algae; water turbid, deep; weather cloudy to passing showers.
Ninth	19.0	37.2	22.2	8.1	Do.
Tenth	18.7	57.3	24.6	8.1	Pond newly freshened, water turbid, deep; weather clear, calm, partly cloudy.
Eleventh	18.7	70.1	22.8	8.1	Pond was drained, very turbid deep; weather overcast to changeable.
Twelfth	18.3	155.2	35.9	8.0	Water newly freshened, turbid, deep; weather calm cloudy to overcast.
Thirteenth	10.9	42.7	39.0	7.5	Algae dying, disintegrating; water very turbid, deep; weather very stormy.
Fourteenth	13.0	35.1	23.3	7.4	Pond was drained, water very turbid deep; weather generally fair.
Fifteenth	13.1	59.5	21.3	7.3	Algae dying, disintegrating, water turbid, deep; weather generally clear.
Sixteenth	20.9	18.8	27.6	7.3	Experiment due.

were mainly influenced by variation in rainfall during the period.

The pH appeared within normal limits prevailing in bañgos ponds, that is, it remained at slightly basic conditions ranging from 7.1 to 8.6 with an average of 7.7 for the first experiment and 7.2 to 8.1 with an average of 7.7 for the second experiment. The lack of abnormal values for pH shows that it is not a very important factor in lumut growth in the ponds.

The depth of the pond water was hard to control with the soil dikes and wooden gates but it remained low enough for normal growth of lumut. Rapid rises of the depth during a short duration due to rainfall or leaks from the dikes occurred, but these have not produced any significant effect on the results of the experiments.

Both experimental periods were not completely devoid of rainfall. During the first experiment, the drier period, the weekly total of rain varied from nil to 130.1 millimeters. During the second experiment, which was the rainy period, there was no week that was devoid of rain, with the weekly total ranging from as low as 18.6 millimeters to as high as 213.5 millimeters.

Except probably for salinity which remained at consistently high level during the first experimental period and comparatively lower during the second experimental period, the other factors mentioned (pH, rainfall and depth of water) did not affect lumut growth very much. The higher salinity recorded

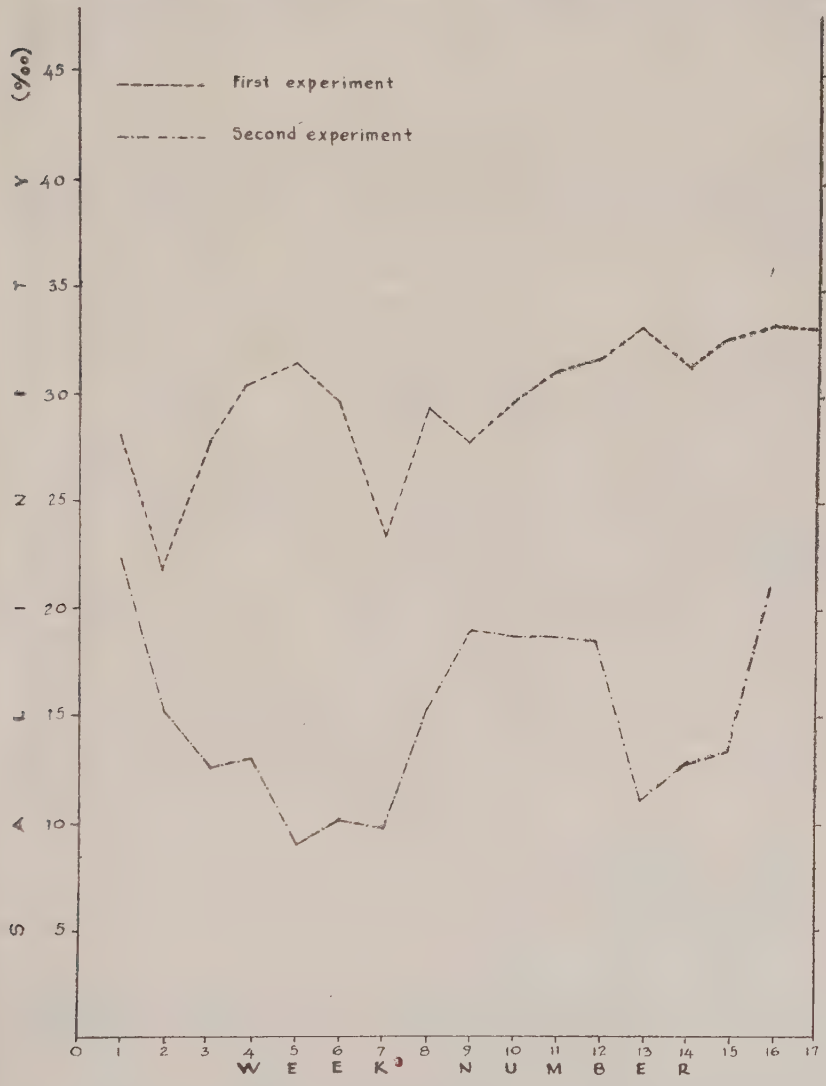

Fig. 4. Comparative salinity observations for the experimental ponds during first and second experiments.

during the period may have inhibited maximum growth of lumut during the first experimental period and explain the comparatively higher level of growth during the second experimental period.

The weather conditions varied from fair to inclement during the period. There were occasional showers, rains, winds and even storm.

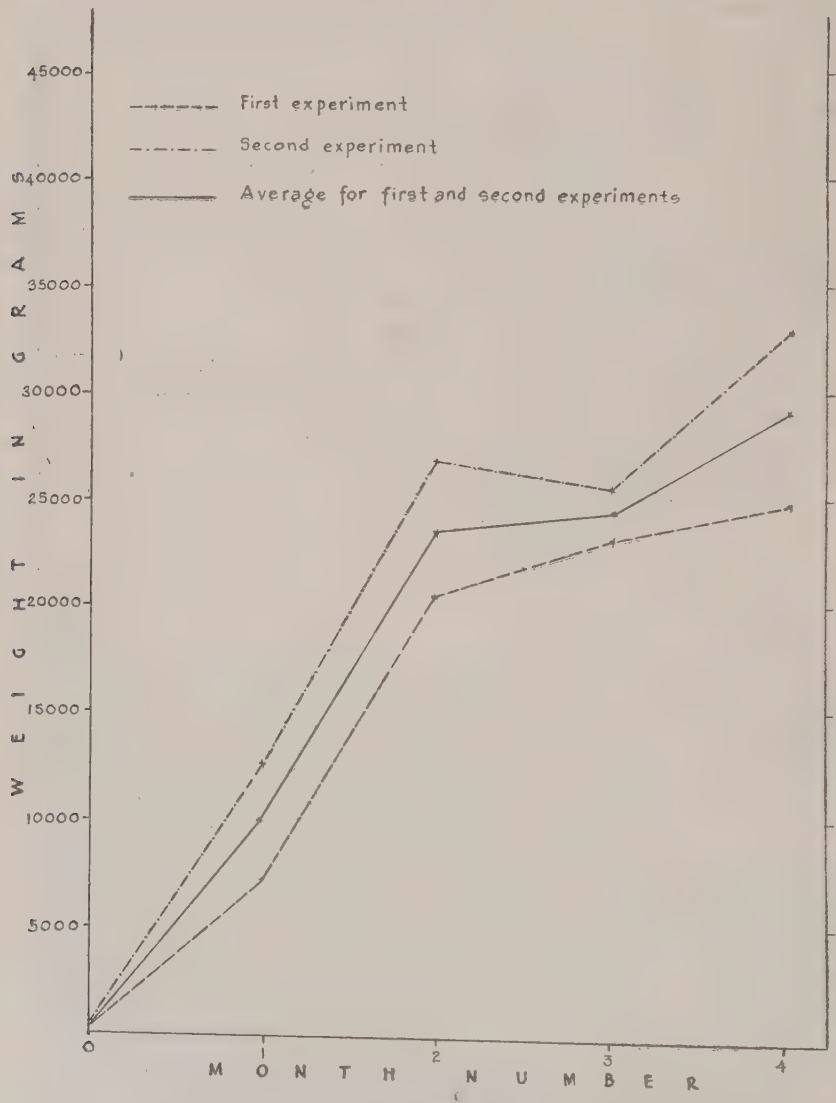

FIG. 5. Average monthly increase in weight of lumut in experimental ponds I to VI.

General observations on algæ growth (Tables 10, 11 and 12, and fig. 5).—The lumut has been observed to have undergone

a cycle of growth period and disintegration or death period as shown by regular ocular examination and the results obtained in weighing the algæ. When one of these processes prevailed, it exerts a profound effect leading in the sharp fluctuations in the rate of growth of the lumut. The duration of lumut culture necessary and the pond capacity for such growth as shown by the experiments are of value to bañgos fishpond raisers.

CONCLUSIONS

All the ponds showed a very rapid rate of growth of lumut during the first few weeks but later this growth leveled off or becomes slight and even actual decreases were recorded.

TABLE 10.—*Average monthly increase in weight of lumut in Experimental Ponds I to VI*

[First experiment]

Pond number	Initial stock (gm.)	Weight after one month (gm.)	Weight after two months (gm.)	Weight after three months (gm.)	Weight after four months (gm.)
I	549.8	3,245.8	11,061.0	35,320.4	22,906.8
II	438.7	3,167.2	788.3	87.5	1
III	351.9	4,996.5	39,264.8	33,368.0	25,684.0
IV	326.0	[a]	[a]	[a]	34,020.6
V	354.2	18,466.5	31,100.3	24,699.2	40,427.0
VI	442.0	[a]	[a]	[a]	25,770.0
Totals	2,462.6	29,876.0	82,214.4	93,475.1	148,808.1
Average per pond	410.4	7,469.0	20,553.6	23,368.7	24,801.6
Average per square meter	8.2	149.4	411.0	467.3	498.4

[a] No record hence not used in computing averages

TABLE 11.—*Average monthly increase in weight of lumut in Experimental Ponds I to VI*

[Second experiment]

Pond number	Initial stock (gm.)	Weight after one month (gm.)	Weight after two months (gm.)	Weight after three months (gm.)	Weight after four months (gm.)
I	773.4	10,631.2	26,592.3	20,865.6	14,515.2
II	778.7	7,796.2	14,288.4	8,391.0	4,989.6
III	632.8	13,834.8	38,499.3	47,202.7	54,658.8
IV	693.5	[a]	[a]	[a]	29,484.0
V	590.4	18,824.4	28,123.2	26,393.8	46,720.8
VI	662.0	[a]	[a]	[a]	48,988.8
Totals	4,130.8	51,086.6	107,503.2	102,853.1	199,357.2
Average per pond	688.4	12,771.6	26,875.8	25,713.2	33,266.2
Average per square meter	13.7	255.4	537.5	514.3	664.5

[a] No record hence not used in computing averages

TABLE 12.—*Average monthly increase in weight of lumut in experimental Ponds I to VI*

[First and second experiments]

Pond number	Initial stock (gm.)	Weight after one month (gm.)	Weight after two months (gm.)	Weight after three months (gm.)	Weight after four months (gm.)
I	661.6	6,938.5	18,826.7	28,093.0	18,711.0
II	608.7	5,481.7	7,538.4	4,239.3	2,494.8
III	492.3	9,415.6	38,882.0	40,285.3	40,171.7
IV	509.7	[a]	[a]	[a]	31,752.0
V	472.3	18,645.4	29,611.7	25,546.5	43,573.9
VI	552.0	[a]	[a]	[a]	37,379.4
Total	3,296.6	40,481.2	94,858.8	98,164.1	174,082.8
Average per pond	549.4	10,120.3	23,714.7	24,541.0	29,013.8
Average per square meter	10.9	202.4	474.3	490.8	580.3

[a] No record hence not used in computing averages

Lumut growth seems to be very sensitive to changes in environmental conditions such as salinity, rainfall, and depth of pond water, as shown by the sharp rises and falls during the culture period. However, weekly sampling may also be a factor due to frequency of handling. Unfavorable and uncontrollable environmental factors may even lead to complete algal disintegration in the ponds.

The maximum growth attained for these ponds in this experiment was 54,658.8 grams per pond of 50 square meters or equivalent to 1,093.2 grams per square meter.

The average monthly growth of lumut in these ponds during this experiment, expressed in grams per square meter, is 202.4 after one month; 474.3 after two months; 490.8 after three months; 580.3 after four months. First-class bangos ponds with luxuriant growth of lumut may give figures in excess of the above, while the poorest may produce very little if at all. The above figures may be used as a gauge of pond productivity based on the rate of lumut production.

Prolonged culture of lumut may not necessarily result in increased production for the fishpond, as can be seen from this experiment. Maximum algal growth may be attainable during the period between the second and the third month. Only slight increases and even decreases in growth were noticed after this period. Therefore, it is unwise to have a prolonged culture of algæ as this may only lead to waste of time which could have been profitably spent in rearing of the fish under cultivation.

ILLUSTRATIONS

TEXT FIGURES

FIG. 1. Weekly increase in weight of lumut in experimental ponds I and II.

2. Monthly increase in weight of lumut in experimental ponds III and V.

3. Increase in weight of lumut in experimental ponds IV and VI at the end of experimental period.

4. Comparative salinity observations for the experimental ponds during first and second experiments.

5. Average monthly increase in weight of lumut in experimental ponds I to VI.

ENUMERATION OF ALGÆ IN PHILIPPINE BAÑGOS FISHPONDS AND IN THE DIGESTIVE TRACK OF THE FISH WITH NOTES ON CONDITIONS FAVORABLE FOR THEIR GROWTH.

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SUMMARY

Observation showed that out of the 43 species of algæ identified growing in Dagat-dagatan fishponds and the neighboring ponds, *Chaetomorpha* was the most common of the filamentous algæ. *Lyngbya* took the lead and followed by *Phormidium* of the blue-green algæ. Of the diatoms, *Mastogloia*, *Pleurosigma*, *Surirella*, *Chaetoceras*, *Biddulphia*, and *Nitzschia* were found predominant (Table 2).

Intestinal contents of five bañgos yielded 14 species (algæ and diatoms) recognizable and of these, *Chaetomorpha*, *Melosira*, *Navicula*, *Nitzschia*, *Pleurosigma*, and *Coscinodiscus*. Apparently these were taken upon more preferably than others, or they have not been digested when the intestinal contents were examined.

The common algæ and diatoms were sketched in six plates.

Among the 2,000 Philippine food fishes bañgos, *Chanos chanos* (Forskål), is undoubtedly the most important. The culture of this fish has developed into a thriving industry all over the Islands. Bañgos is available all the year round owing to the fact that it can be easily reared in ponds where it grows fast, being largely herbivorous. Moreover, it possesses a palatable flavor relished by the people. The fast rate of growth of bañgos together with its palatable flavor is due to the proper care it receives and the nutrition it gets from the algæ it feeds upon. At other times, cases have been reported of stunted bañgos with a sickening, earthly taste (lasang gilik). This peculiar taste may be due to the kind of food the fish has taken.

Algæ in fishponds, besides constituting the main bulk of natural food supply of the bañgos, serve as an excellent aerator in the pond. They purify and increase the biological productivity of the pond by providing shelter and attachment for epiphytic green and blue-green algæ as well as for other planktonic organisms.

Since algæ in general constitute the principal food of bañgos from the fry stage until it reaches marketable size it is essential that a detailed knowledge of the different kinds of algæ in a fishpond be secured. The objects of this work are:

a. To make a systematic classification of the algæ available in a fishpond.

b. To know the conditions favorable for their rapid growth by making observations on algal culture.

c. To know what kinds of algæ are actually being used as food by the bañgos by examining the stomach and intestinal contents.

The work was carried out during the first semester of the school year 1947–1948. The first collection was started on June 12, 1947 and the last on September 10, 1947 at the Dagatdagatan Fishery Experimental Station, Malabon, Rizal Province. Other collections were also made from a neighboring fishpond to make a comparison.

LITERATURE

"Diatoms have for many years been recognized as an extremely important source of food for planktonic animals." Haeckel (1890), Johnstone (1908), Lohman (1911), Gram (1912, 1930, 1931), Lebour (1921, 1922, 1923), Herdman (1923), Bigelow (1926), and Allen (1934) have published valuable discussions of the problems involved in the abundance of life in the sea.

Johnstone (1908) states: "The Diatomaceae are above all the most important organisms in the sea regarded from the point of view of their significance as producers of organic substance." The diatoms are the 'pastures of the sea' and corresponds to the 'grass of the land.' Gram (1930) wrote: "These enormous quantities of diatoms without doubt are the most important food for the pelagic copepod and indirectly for the fish larvae which develop after the great spring spawning period." Phifer (1923) likewise wrote: "Marine plants are the principal source upon which the fauna of the oceans depends for the energy necessary for existence. Undoubtedly the shore algæ produce organic material forming nutritive substance for bacteria which in turn are probably consumed by small protozoa. However, the phytoplankton are directly consumed and produce organic food in much larger quantities in as much as the real extent of their distribution is many times greater than that of the

shore forms. Of the groups in the phytoplankton such as diatoms, dinoflagellates, algal spores, cocolithopores, the first mentioned unicellular plants play the major role in the temperate seas."

Whipple (1927) states: "The fact that plankton are sensitive to changes in their environment make them good indicators of pollution and self-purification." Larger in size and more readily identifiable than bacteria, they offer an attractive means of gaging conditions of existence and with it the sanitary status of streams.

MATERIALS USED

Plankton net, research microscope, salinometer, thermometer, graduated cylinder, collecting spade, preserving bottles, presser and preserving fluids: Transeau's solution (for phytoplankton), and 10 per cent formalin.

PROCEDURE

Available algæ in both the rearing ponds and the nurseries were collected and preserved. Collections and observations were made once a week from June 10, 1947 to September 10, 1947 at the Dagat-dagatan Saltwater Fishery Experimental Station, Malabon, Rizal, and also from nearby fishponds for comparison. Specimens of phytoplankton which were collected by passing sufficient quantity of pond water through a plankton net were preserved in Transeau solution.

Lab-lab samples were collected with the aid of an improvised spade (a tin sheet attached to a long bamboo pole). These samples were then spread and dried on newspaper sheets. Before the samples were thoroughly dried they were studied under a microscope for identification and classification. Different kinds of growths were selected everytime a collection was made.

Algal growths observed on bamboo stakes, ceramic slabs, concrete gates, as well as wooden gates were collected by scrapping them with the aid of a knife. Specimens collected were spread and dried on newspaper sheets after they have been identified and classified.

Filamentous green algæ found growing on different parts of the pond were collected, spread and dried on newspaper sheets. A representative of each specimen collected was isolated, pressed, and dried.

Data were taken as to algal growth, air temperature, salinity, and water temperature including weather condition every time a collection was made.

Various sizes of bangos from different ponds were caught and dissected. The digestive organs were preserved and the stomach and intestinal contents of each specimens were studied, identified and classified. Data were also taken as to the size and weight of each fish caught.

COLLECTION RECORD NO. 1

Locality ..... Dagat-dagatan, Malabon, Rizal.
Date ..... 12 June 1947.
Time ..... 0900 A. M.
Water temperature ..... 37° C.
Air temperature ..... 32° C.
Salinity 10
Weather ..... Cloudy.

Observations:

N P[1] No. 1: Growth of dark green lab-lab was observed at the bottom but filamentous green algæ along the sides.

N P No. 2, 3: Luxuriant growth of filamentous green algæ all over these two ponds was noticeable.

N P No. 5: Thin growth along the north side of the pond but at center without any growth; thin growth on substratum at the south end was observed.

N P No. 6: Thick greenish white growth of lab-lab at the northeast side of the pond predominating.

N P No. 7: Growth of dark green lab-lab at the north and northeast side, prominent.

R P[2] No. 1: Growth of filamentous green algæ along the sides of the ponds only.

R P No. 2, 11: No algal growth seen.

Plankton Collection:

Nurseries:
Pleurosigma–A
Lyngbya

Sample A–1
Navicula
Mastogloia–A

Rearing Ponds—Sample A–2: *Peridinium venustum*, *Thalastiothrix*, *Ditylum*, *Coscinodiscus*, *Rhizosolenia*, *Pleurosigma*, *Syndra*, *Ceratium furca*, *Lauderia Mastogloia*, *Dinophysis*, *Biddulphia*, *Surirella*, *Hemiaulus*, and *Chaetocerus*.

Nursery Pond No. 6–Sample No. 1: *Oscillatoria*, *Mastogloia*, *Phormidium*.

Nursery Pond No. 7–Sample No. 2: *Lyngbya*, *Pleurosigma*, *Mastogloia*, *Oscillatoria* (Fine strands), *Phormidium*.

Nursery Pond No. 7–Sample No. 3: *Oscillatoria*, *Lyngbya*, *Phormidium*.

[1] NP means nursery pond.
[2] RP means rearing pond.

Nursery Pond No. 5–Sample No. 4: *Oscillatoria, Pleurosigma* (tiny), *Mastogloia.*
Nursery Pond No. 6–Sample No. 5: *Lyngbya, Oscillatoria, Mastogloia.*
Rearing Pond No. 2—Sample No. 6: *Chaetomorpha.*

COLLECTION RECORD NO. 2

Locality	Dagat-dagatan, Malabon, Rizal.
Date	18 June 1947.
Time	100 A.M.
Water temperature	30° C.
Air temperature	29.5° C.
Salinity	10.5
Weather	Sunny

Observations:

R P No. 1: Water was 2 feet deep with algal growth along sides of the pond only. Thin encrustations observed attached to the bottom which is muddy.

N P No. 5: Lab-lab growth poor. Dark bottle green color at Northwest corner of the pond. Thin growth of similar algæ collected at the center of the pond.

N P No. 6: Algae composed of thick blanket-like growth that begins to peel off from the substratum. Lab-lab is conspicuously colored yellow-green. Strands obviously old.

N P No. 7: Algæ of the dirty-green color predominating. Strands appear course with ends still attached to the substratum. Vertical growth scarcely reaching the surface of the water.

Plankton Collection:

Nurseries—Sample B–1: *Favella, Coscinodiscus, Ditylum, Pleurosigma, Ceratium furea, Dinophysis, Pediastrum.*
Rearing Pond—Sample B–2: *Peridinium, Pediastrum, Favella, Phormidium.*

Algal Collections:

Rearing Pond No. 1—Sample No. 7: *Phormidium, Anabaena, Mastogloia.*
Rearing Pond No. 2—Sample No. 8: *Enteromorpha intestinalis.*
Nursery Pond No. 5—Sample No. 9: *Lyngbya, Pleurosigma, Mastogloia.*
Nursery Pond No. 6—Sample No. 10: *Lyngbya, Pleurosigma.*

COLLECTION RECORD NO. 3

Locality	Dagat-dagatan, Malabon, Rizal.
Date	25 June 1947.
Time	0900 A.M.
Water temperature	30°C.
Air temperature	26.7°C.
Salinity	7
Weather	Showering.

Observations:

N P No. 1: Thick growth of *Chaetomorpha* covering surface of the pond. Some patches of *Enteromorpha* are entangled with the old strands of *Chaetomorpha.* No lab-lab observed on the bottom.

N P No. 5: Filamentous blue-green algæ are starting to grow towards the surface of the water at the south end of the pond.

N P No. 6: Small patches of thin growth of lab-lab could be seen all along the pond. Cakes of floating blue-green algæ floating at the south end.

N P No. 7: Thick growth of blue-green algae is found all over the pond.

R P No. 1: Sparse growth of *Enteromorpha* along the sides.

Plankton Collection:

Nurseries—Sample C–1: *Pleurosigma* (fine A), *Lyngbya, Mastogloia, Surirella.*

Rearing Pond—Sample C–2: *Chaetoceras* (Tiny A.), *Surirella, Lyngbya, Pleurosigma, Tintinnopusis.*

Algæ:

Nursery Pond No. 5—Sample No. 11: *Lyngbya, Microcoleus.*

Nursery Pond No. 6—Sample No. 12: *Oscillatoria, Mastogloia, Spirulina, Anabaena, Phormidium, Pleurosigma.*

Nursery Pond No. 7—Sample No. 13: *Lyngbya.*

COLLECTION RECORD NO. 4

Locality	Dagat-dagatan, Malabon, Rizal.
Date	27 June 1947.
Time	0900 A. M.
Water temperature	30° C.
Air temperature	28.8° C.
Salinity	8
Weather	Sunny.

Observations:

Nursery Ponds: These ponds were dried out and lab-lab was observed to be floating on all parts of the pond. On parts of the pond has dried, the scum was seen to grow on top of the mud.

Rearing Ponds: Water was deep and algal growth was observed floating only along the sides and corners of the pond. The water has newly been changed so abundant phytoplankton was expected.

Plankton Collection:

Rearing Ponds—Sample D–7: *Chaetoceras, Biddulphia, Talassiothrix, Ditylum, Bacteriastrum, Surirella, Coscinodiscus, Rhizosolenia, Pleurosigma, Melosira, Navicula, Nitzchia, Coretron, Planktonisllla, Lauderia, Clamydomonas, Marismopedia, Certium.*

Algæ:

Nursery Pond No. 6—Sample No. 15: *Lyngbya.*

Nursery Pond No. 1—Sample No. 16: *Lyngbya, Phormidium.*

Rearing Pond No. 5—Sample No. 17: *Chaetomorpha.*

Rearing Pond No. 6—Sample No. 18: *Chaetomorpha.*

COLLECTION RECORD NO. 5

Locality ..... Dagat-dagatan, Malabon, Rizal.
Date ..... 2 July 1947.
Time ..... 0900 A. M.
Water temperature ..... 29.9° C.
Air temperature ..... 28.2° C.
Salinity 5.5
Weather ..... Sunny.

Observations:

N P No. 1: Thick growth of filamentous green algæ all around the pond and some patches turning brownish in color were observed.

N P No. 5, 6, 7: Algæ collected were from those attached to the substratum. No floating algæ present. Water in these ponds were deep due to heavy rain. The vertical growth of filamentous algæ were not long enough to enable them to reach the surface of the water.

R P No. 1: Algal growth found only along the sides and corners of the ponds. Some patches growing on submerged pieces of ceramics. No growth whatsoever was observed in other rearing ponds.

Phytoplankton Collection:

Rearing Ponds—*Planktoniella, Pleurosigma, Lauderia, Ditylum, Navicula, Biddulphia, Thalassiothrix, Chactocerus, Corsthron, Bacillaria, Asterinella, Bacteriastrum, Ceratium, Favella, Coscinodiscus, Rhizosolenia, Peridinium, Nitzschia, Surirella, Gyrosigma.*

Nurseries—*Surirella, Pleurosigma, Gyrosigma, Synedra, Peridinium, Mastogloia.*

Algæ:

Nursery Pond No. 7—Sample No. 19: *Lyngbya, Oscillatoria, Mastogloia.*

Nursery Pond No. 6—Sample No. 20: *Lyngbya, Oscillatoria.*

Nursery Pond No. 5—Sample No. 21: *Lyngbya* (old strands).

COLLECTION RECORD NO. 6

Locality ..... Camus Fishpond, Navotas, Rizal.
Date ..... July 4, 1947.
Time ..... 10:00 A.M.
Water temperature ..... 33° C.
Air temperature ..... 30° C.
Salinity 5
Weather ..... Sunny.

Observations:

N P No. 1: This pond has been drained out. Lab-lab was seen to be growing on the surface of the drying mud. A few cakes of lab-lab floating near the gate.

R P No. 6: No growth of algæ observed at the middle of the pond. A few patches of green algæ along the sides and corners.

Phytoplankton:

R P No. 6: *Thalassiothrix, Corethron, Chaetoceras, Pleurosigma, Navicula, Ditylum, Rhizosolenia, Ceratium, Coscinodiscus, Biddulphia, Peridinium.*

Nursery Pond No. 1: *Oscillatoria, Navicula, Pleurosigma, Surirella, Lyngbya, Rhizosolenia, Mastogloia.*

CNP No. 1: *Chaetomorpha, Phormidium, Tiny Pleurosigma, Mastogloia.* Sample No. 23.

CNP No. 1: Sample No. 22 *Lyngbya, Enteromorpha, Mastogloia.*

CNP No. 1: Sample No. 24 *Lyngbya* (small).

CNP No. 5: Sample No. 25: *Enteromorpha.*

CRP No. 6: Sample No. 26: *Chaetomorpha.*

COLLECTION RECORD NO. 7

Locality	Dagat-dagatan, Malabon, Rizal.
Date	9 July 1947.
Time	10:00 A. M.
Water temperature	31° C.
Air temperature	29° C.
Salinity	5
Weather	Showering.

Observations:

NP No. 1: Abundant growth of *Chaetomorpha* covering the pond but no lab-lab growth was observed.

NP No. 5, 6, 7: Water in this pond was deep and no algal growth seen.

RP No. 1, 3, 6: Growth of filamentous green algæ on the sides and corners of the pond was common.

Phytoplankton:

RP No. 6: *Biddulphia, Chaetoceras, Pleurosigma, Corethron, Pediastrum, Coscinodiscus, Navicula, Rhizosolenia, Nitzschia.*

NP No. 2: *Amphiprora, Mastogloia, Stauroneis, Pleurosigma, Navicula, Thalassiothrix.*

NP No. 2: Sample 27: *Lyngbya, Chaetomorpha, Characium* (epiphitic on *Chaetomorpha*).

NP No. 3: Sample No. 28: *Aphanocapsa, Chaetomorpha.*

RP No. 2: Sample No. 29: *Lyngbya.*

COLLECTION RECORD NO. 8

Locality	Meycauayan, Bulacan.
Date	14 July 1947.
Time	10:45 A. M.
Water temperature	33.5° C.
Air temperature	30° C.
Salinity	0
Weather	Sunny.

Observations:

Rearing Pond: There was abundant growth of *Rupia* (Digman) intertwined with growths of *Cladophora* and *Chaetomorpha.* At one corner of the pond were newly planted *Cladophora.*

Nursery Pond: This pond had growth of lab-lab at one end which was drying up.

Phytoplankton Collection:

Navicula, Pleurosigma, Amphiprora, Lyngbya.
Nursery Pond—Sample No. 30: *Anabaena.*
Sample No. 31: *Cladophora.*
Sample No. 32: *Chaetomorpha, Melosira.*
Sample No. 33: *Chaetomorpha.*
Sample No. 34: *Lyngbya.*
Sample No. 35: *Hormidium.*

COLLECTION RECORD NO. 9

Locality ..... Dagat-dagatan, Malabon, Rizal.
Date ..... 15 July 1947.
Time ..... 9:00 A. M.
Water temperature ..... 35° C.
Air temperature ..... 30° C.
Salinity 8
Weather ..... Sunny.

Observations:

NP No. 5, 6, 7: With water deep due to strong rain the previous day.

NP No. 5: Lab-lab growth very poor appearing only at corners.

NP No. 6: Thick growth of blanket algæ peeling off from substratum. Conspicuously colored green, obviously old.

NP No. 7: Young and old growths appeared together making a dirty green in color. Vertical strands observed, with ends still attached to the substratum.

NP No. 2: Thick growth of filamentous green algæ scattered in patches all over the pond. Occasionally at different parts of the pond were lab-lab growth on top of *Chaetomorpha* filaments.

RP No. 1: Lab-lab growth at the sides and corner of the pond.

RP No. 3: Patches of lab-lab along the sides.

Phytoplankton:

Rearing Pond: *Biddulphia–A, Coscinodiscus, Lauderia, Ditylum, Corethron, Nitzschia, Pleurosigma, Chaetomorpha, Thalassiothrix, Synedra.*
Nursery Pond: *Coscinodiscus, Biddulphia, Ditylum, Corethron, Pleurosigma, Thalassiothrix, Synedra, Chaetoceras.*
NP No. 3: Sample No. 36: *Chaetomorpha, Enteromorpha.*
NP No. 4: *Phormidium, Oscillatoria, Spirulina–R.*
RP No. 1: Sample No. 38: *Lyngbya.*
RP No. 2: *Gleocapsa.*
RP No. 3: Sample No. 40: *Oscillatoria.*

COLLECTION RECORD NO. 10

Locality ..... Dagat-dagatan, Malabon, Rizal.
Date ..... 23 July 1947.
Time ..... 9:00 A.M.

Water temperature ..... 28° C.
Air temperature ..... 27° C.
Salinity 5.5
Weather ..... Sunny.

Observations:

NP No. 1: No green algæ Lab-lab growth seem starting on bottom of pond.

NP No. 2, 3: Abundant growth of filamentous green algæ mostly mature *Chaetomorpha* in both ponds. Lab-lab growth on top of the filaments.

NP No. 5: Lab-lab growth on pond bottom starting to peel off.

NP No. 6: Old growth of lab-lab observed on the bottom apparently dying off.

NP No. 7: Lab-lab growth on south end of the pond obviously new growths.

RP No. 1: Filamentous green algæ along sides of the pond.

Phytoplankton:

Nursery Pond: *Surirella*–A, *Pleurosigma*–A, *Ditylum, Mastogloia, Navicula, Pediastrum, Bacillaria, Melosira, Biddulphia.*
RP No. 1—Sample No. 41: *Enteromorpha, Chaetomorpha.*
NP No. 2—Sample No. 42: *Chaetomorpha, Lyngbya.*
NP No. 6—Sample No. 43: *Lyngbya, Chaetomorpha.*
NP No. 6—Sample No. 44: *Lyngbya.*

COLLECTION RECORD NO. 11

Locality ..... Dagat-dagatan, Malabon, Rizal.
Date ..... August 1947.
Time ..... 4:00 P. M.
Water temperature ..... 34° C.
Air temperature ..... 28° C.
Salinity 3
Weather ..... Overcast.

Observations:

RP No. 1: Abundant growth of *Chaetomorpha* and some *Enteromorpha* in deep water. Algal growth mostly along sides and corners of pond seen.

RP No. 2, 3, 4: No algal growth observed.

NP No. 1: Very scarce growth of lab-lab.

NP No. 2, 3: Luxuriant growth of *Chaetomorpha*, with patches of lab-lab growing on floating filaments.

Phytoplankton:

Rearing Pond: *Pleurosigma, Surirella, Ditylum, Mastogloia*–A.
Nursery Pond: *Pleurosigma, Mastogloia, Surirella, Coscinodiscus, Navicula, Amphiprora, Biddulphia, Navicula.*
NP No. 6—Sample No. 45: *Lyngbya.*
NP No. 2—Sample No. 46: *Chaetomorpha.*
NP No. 7—Sample No. 47: *Surirella, Anabaena, Lyngbya, Mastogloia, Microcoleus, Oscillatoria.*

NP No. 2—Sample No. 48: *Chaetomorpha, Lyngbya.*
RP No. 1—Sample No. 49: *Enteromorpha, Chaetomorpha.*

COLLECTION RECORD NO. 12

Locality	Dagat-dagatan, Malabon, Rizal.
Date	6 August 1947.
Time	10:00 A. M.
Water temperature	32° C.
Air temperature	31° C.
Salinity	5
Weather	Sunny.

Observations:

Nursery Ponds: NP Nos. 5, 6, 7, being drained for lab-lab culture. Young growths observed in NP Nos. 5 and 7. Filamentous green algæ abundant in NP Nos. 2 and 3.

Rearing Ponds: Filamentous green algæ growing in RP No. 1 mostly along the sides and corner. No algal growths observed in other rearing ponds.

Phytoplankton:

Nursery Ponds: *Pleurosigma–A, Surirella–A, Biddulphia, Mastogloia, Amphiprora–A, Melosira.*
Rearing Ponds:*Pleurosigma, Surirella, Amphiprora–A, Ditylum, Rhizosolenia, Navicula, Melosira, Mastogloia, Nitzschia, Chaetoceras.*
NP No. 2—Sample No. 51: *Chaetomorpha.*
NP No. 3—Sample No. 52: *Lyngbya, Anabaena.*
NP No. 3—Sample No. 53: *Enteromorpha.*
NP No. 6—Sample No. 54: *Lyngbya.*

COLLECTION RECORD NO. 13

Locality	Dagat-dagatan, Malabon, Rizal.
Date	13 August 1947.
Time	2:00 P.M.
Water temperature	34°C.
Air temperature	30°C.
Salinity	0
Weather	Showering

Observations:

Nursery Ponds: Water deep due to storm and continuous rain for two days and two nights. No lab-lab growth observed except on top of filamentous green algæ and patches on the bottom of NP Nos. 5 and 7.

Rearing Ponds: Water deep in rearing ponds. Green algæ in RP No. 1 were all under water. No other growths observed.

Phytoplankton:

Nursery Ponds: Pleurosigma, Mastogloia, Amphiprora
Rearing Ponds: *Nitzschia, Ditylum, Navicula, Amphiprora, Mastoglia, Biddulphia.*
RP No. 1—Sample No. 56: *Enteromorpha, Chaetomorpha.*

RP No. 1—Sample No. 57: *Chaetomorpha.*
RP No. 2—Sample No. 58: *Lyngbya.*
RP No. 2—Sample No. 59: *Lyngbya.*
NP No. 5—Sample No. 60: *Chaetomorpha.*
NP No. 6—Sample No. 61: *Lyngbya.*
NP No. 7—Sample No. 62: *Lyngbya.*

COLLECTION RECORD NO. 14

Locality ..... Dagat-dagatan, Malabon, Rizal.
Date ..... 20 August 1947.
Time ..... 2:00 P.M.
Air temperature ..... 31°C.
Water temperature ..... 28°C.
Salinity 3
Weather ..... Cloudy.

Observations:

Nursery Ponds: No algal growth in RP No. 1. Green algæ mostly *Chaetomorpha* abundant in RP No. 2, 3 conspicuously old with a yellow greenish color. Very scarce algal growth in NP No. 4. New growths of Lab-lab observed in Nos. 5 and 6. Floating lab-lab in NP No. 7, dark green in color.

Rearing Ponds: Old filaments of *Chaetomorpha*, yellow green in color intertwined with young filaments of floating Enteromorpha at different parts of the pond specially along the sides and corners.

No algal growth in other rearing ponds observed.

Phytoplankton:

Rearing Ponds: *Biddulphia, Nitzschia, Pleurosigma, Chaetoceras, Navicula–A, Mastogloia, Ditylum, Chamaesiphon, Surirella, Coscinodiscus.*

Nursery Ponds: *Amphiprora, Melosira, Pleurosigma, Navicual, Nitzschia, Amphora, Mastogloia Chaetoceras.*

RP No. 1—Sample No. 63: *Chaetomorpha, Enteromorpha.*
NP No. 1—Sample No. 64: *Chaetomorpha, Enteromorpha.*
NP No. 2—Sample No. 65: *Lyngbya, Chaetomorpha.*
NP No. 5—Sample No. 66: *Lyngbya, Microcoleus.*
NP No. 6—Sample No. 67: *Lyngbya, Microcoleus.*

COLLECTION RECORD NO. 15

Locality ..... Dagat-dagatan, Malabon, Rizal.
Date ..... 27 August 1947
Time ..... 9:00 A.M.
Water temperature ..... 31°C.
Air temperature ..... 27°C.
Salinity 2
Weather ..... Cloudy.

Observations:

Nursery Pond No. 1: No lab-lab growth observed today.

Nursery Pond No. 2, 3: Luxuriant growth of filamentous green algæ (*Chaetomorpha*) in both ponds. Lab-lab growth observed on top of filamentous green algæ.

NP No. 46: No algal growth visible.

NP No. 5, 6, 7: Growth of *Rupia* observed. Lab-lab growth very scarce.

RP No. 1: *Chaetomorpha* and *Enteromorpha* growth observed along sides and corner of the pond.

No algal growth in other ponds.

Phytoplankton:

Rearing Ponds: *Chaetoceras–A, Ditylum, Merismopedia–B, Biddulphia, Melosira, Coscinodiscus, Pleurosigma, Thalassiothrix, Surirella, Rhisosolenia, Nitzschia, Mastogloia, Navicula.*

Nursery Ponds: *Pleurosigma, Surirella, Navicula, Coscinosdiscus, Biddulphia, Ditylum, Chaetoceras.*

RP No. 1—Sample No. 69: *Enteromorpha.*
RP No. 1—Sample No. 70: *Cladophora.*
NP No. 2—Sample No. 71: *Lyngbya.*
NP No. 4—Sample No. 72: *Lyngbya.*
NP No. 6—Sample No. 73: *Lyngbya, Chaetomorpha.*

COLLECTION NO. 16

Locality	Dagat-dagatan, Malabon, Rizal.
Date	3 September 1947.
Time	10:00 A.M.
Water temperature	29°C.
Air temperature	28°C.
Salinity	0
Weather	Sunny.

Observations:

NP No. 1: No algal growth visible whatsoever.

NP Nos. 2, 3: Abundant, ripe-yellow filamentous green algæ with occasional growths of lab-lab on top of filaments.

NP No. 4: No algal growth.

NP Nos. 5, 6, 7: Very scarce growth of lab-lab but abundant growth of *Rupia* (digman) due to low salinity of water.

RP No. 1: *Enteromorpha, Chaetomorpha,* and *Cladophora,* growing along sides and corners of pond.

RP No. 2: No algal growth except on pieces of ceramics that have been submerged in water.

RP Nos. 3–11: No algal growth.

NP No. 2. Gelatinous bottle-green algæ collected. Found growing among the roots of grasses partially submerged in water.

Phytoplankton:

Rearing Ponds: *Ditylum–A, Surirella, Pleurosigma, Coscinodiscus, Nitzschia, Melosira, Navicula, Biddulphia, Amphiprora, Chaetoceras.*

Nursery Ponds: *Biddulphia–A, Coscinodiscus–A, Pleurosigma, Ditylum, Thalassiothrix, Lauderia, Melosira.*

NP No. 5—Sample No. 74: *Lyngbya, Melosira.*
NP No. 3—Sample No. 75: *Lyngbya, Cladophora.*
NP. No. 2—Sample No. 76: *Cladophora, Lyngbya.*
NP No. 2—Sample No. 77: *Aphanocapsa.*
RP No. 2—Sample No. 78: *Chaetomorpha.*

COLLECTION RECORD NO 17

Locality	Dagat-dagatan, Malabon, Rizal.
Date	10 September 1947.
Time	10:00 A. M.
Water temperature	30°C.
Air temperature	28°C.
Salinity	2
Weather	Sunny.

Observations:

NP No. 1: No algal growth.

NP Nos. 4, 5: Luxuriant growth of mature filamentous green algæ with patches of lab-lab on top of floating filaments. Intermingled with the green algæ are growth of *Rupia* and *Chara.*

Nursery Pond No. 4: No algal growth.

Nursery Pond Nos. 5, 6, 7: These ponds were drained and dried, preparatory to cultivation of lab-lab.

Rearing Pond No. 1: Filamentous green algæ, *Chaetomorpha* and *Cladophora* growing luxuriantly. Growth of Rupia abundant.

RP Nos. 2–11: No algal growth except on bamboo stakes.

Phytoplankton:

Rearing Ponds: *Ditylum, Navicula, Surirella, Pleurosigma, Merismopedia, Melosira, Oscillatoria.*

Nursery Ponds: *Melosira-A, Amphiprora, Surirella, Chaetoceras, Spirulina, Coscinodiscus, Pleurosigma, Navicula.*

NP No. 2—Sample No. 79: *Cladophora, Lyngbya.*
NP No. 1—Sample No. 80: *Nostoc, Cladophora.*
NP No. 1—Sample No. 81: *Cladophora, Lyngbya.*

COLLECTION RECORD

Stomach and Intestinal Contents of Bañgos

Fish No. 1

Locality	RP No. 1, Dagat-dagatan.
Date	4 October 1947.
Total length	6.9 cm.
Standard length	5.3 cm.
Depth	1.3 cm.

Stomach contents: *Chaetomorpha, Pleurosigma, Navicula, Lyngbya, Achnanthes.*

Intestinal contents: *Chaetomorpha, Navicula.*

Fish No. 2

Locality ..... RP No. 9, Dagat-dagatan.
Date ..... 5 October 1947.
Total length ..... 56 cm.
Standard length ..... 41 cm.
Depth ..... 9.5 cm.

Stomach contents: *Pleurosigma, Navicula, Coscinodiscus*

Intestinal contents: None

Fish No. 3

Locality ..... RP No. 7, Dagat-dagatan.
Date ..... 8 October 1947.
Total length ..... 42.5 cm.
Standard length ..... 30.0 cm.
Depth ..... 7.0 cm.

Stomach contents:*Chaetomorpha, Lyngbya, Enteromorpha, Melosira, Cladophora, Coconeis, Navicula, Achnanthes.*

Intestinal contents: *Cladophora, Chaetomorpha, Melosira, Lyngbya, Coconeis, Navicula.*

Fish No. 4

Locality ..... RP No. 1, Dagat-dagatan.
Date ..... 28 October 1947.
Total length ..... 27 cm.
Standard length ..... 22 cm.
Depth ..... 7 cm.

Stomach contents: *Coscinodiscus*–A, *Melosira*,–A, *Chaetomorpha, Enteromorpha, Navicula, Pleurosigma, Mastogloia, Oscillatoria, Lyngbya, Rupia.*

Intestinal contents: *Melosira*–A, *Coscinodiscus, Chaetomorpha, Navicula, Mastogloia.*

Fish No. 5

Locality ..... RP No. 1, Dagat-dagatan.
Date ..... 28 October 1947.
Total length ..... 26 cm.
Standard length ..... 21 cm.
Depth ..... 6 cm.

Stomach contents: *Melosira*–A, *Navicula*–A, *Achnanthes, Lyngbya, Coscinodiscus, Chaetomorpha, Amphiprora, Nitzschia, Mastogloia, Rupia.*

Intestinal contents: *Melosira, Coscinodiscus, Cladophora, Chaetomorpha,* (disintegrating), *Enteromorpha, Navicula, Amphora, Achnanthes, Oscillatoria.*

SYSTEMATIC CLASSIFICATION

Division—SCHIZOPHYTA.

Class—Myxophyceae.

Order—Chroococcales.

Family—Chroococcaceae.
Genus—*Aphanocapsa.*
Genus—*Merismopedia.*
Order—*Hormogonales.*
Suborder—Homocystineae.
Family—Oscillatoriaceae.
Genus—*Oscillatoria.*
Genus—*Spirulina.*
Genus—*Phormidium.*
Genus—*Lyngbya.*
Genus—*Microcoleus.*
Family—Nostocaceae.
Genus—*Nostoc.*
Genus—*Anabaena.*

Division—CHRYSOPHYTA.

Class—Bacillarophyceae.
Section—Centriceae.
Subfamily—Discoideae.
Tribe—Coscinodisceae.
Substribe—Melosirinæ.
Genus—*Melosira.*
Substribe—Coscinodiscinæ.
Genus—*Coscinodiscus.*
Genus—*Planktoniella.*
Subtribe—Lauderinae.
Genus—*Lauderia.*
Genus—*Corethron.*
Subtribe—Rhizosoleniinae.
Genus—*Rhizosolenia.*
Subfamily—Biddulpheideae.
Tribe—Chaetocereae.
Genus—*Chaetoceros.*
Tribe Biddulphiaeae.
Subtribe—Triceratineae.
Genus—*Ditylum.*
Substribe—Biddulphinæ.
Section—Pennates.
Subsection—Araphidae.
Subfamily—Fragilarioideae.
Tribe—Fragilarieae.
Subtribe—Fragilariinae.
Genus—*Synedra.*
Genus—*Thalassiothrix.*
Subsection—Monoraphidae.
Subfamily—Achnantheideae.
Tribe—Achnantheae.
Genus—*Achnanthes.*

Subsection—Biraphidae.
Subfamily—Naviculaoideae.
Tribe—Naviculeae.
Genus—*Navicula.*
Genus—*Pleurosigma.*
Genus—*Gyrosigma.*
Genus—*Mastogloia.*
Tribe—Amphiproreae.
Genus—*Amphiprora.*
Subfamily—Nizschioideae.
Tribe—Nitzschieae.
Genus—*Nitzschia.*
Subfamily—Surirelleideae.
Tribe—Surirelleae.
Genus—*Surirella.*

Division—CHLOROPHYTA.
Class—Chlorophyceae.
Order—Ulvales.
Family—Ulvaceae.
Genus—*Enteromorpha.*
Order—Ulothricales.
Suborder—Cladophorieae.
Family—Cladophoraceae.
Genus—*Cladophora.*
Genus—*Chaetomorpha.*

Division—PYRROPHYTA.
Class—Dinophyceae.
Order—Dinoflagellata.
Family—Peridinidae.
Genus—*Peridinium.*
Genus—*Ceratium.*
Family—Dinophysidae.
Genus—*Dinophysis.*

FIELD OBSERVATION OF THE LOCAL CULTIVATION OF ALGÆ

Preparation of the nursery pond.—The pond is first dried by letting out all water during low tide. Water that still remains at the gate or its vicinity is bailed or pumped out. All dirt and debris like grasses and other weeds are removed. Animals such as eels and snakes are eradicated. The pond bed is then thoroughly leveled with the use of a wooden rake and exposed to sunlight for a period of two weeks. Exposure for such a period serves to kill bañgos fry enemies, such as the eggs and fry of predatory species. It also helps to hasten the growth of blue-green algæ on the mud crust.

After exposing the pond bottom for such a length of time and the growth of lab-lab is observed, water is allowed to enter into the pond to a depth of one or two inches. The scum that has formed tends to float or peel off, and the patches that do not float just thickens. This scum or mudcrust which is locally known as *lab-lab* serves as the food of bangos fry.

Preparation of the rearing pond.—The water of a rearing pond which is intended for the cultivation of "lumut" (green algæ) is first drained out. The pond is then washed two or three times by letting water in and out of the pond. After washing, the pond bottom is exposed to sunlight for two weeks. During this period, predatory species such as eels and snakes are removed from the pond bed. Whenever there is luxuriant growth of lab-lab forming on the mud crust it is scraped off. This is done to prevent the lab-lab from forming a blanket over the newly growing lumut green algæ.

After exposing the pond bed for two weeks, water is allowed to enter into the pond to a depth of four inches. Filamentous green algæ, *Chaetomorpha, Cladophora,* and *Enteromorpha*, are then planted at a distance of two meters. In ponds where green algæ has newly been planted, the water is kept at a depth of not more than six inches. This is done to allow the algæ to grow and have a more firm attachment to the bottom. Whenever the water in the pond becomes deep, the newly growing green algæ floats and are pulled off from their attachment, so it is necessary to keep the water at a constant low depth.

RECOMMENDATIONS

1. It is recommended that experiments be carried on the use of artificial fertilizers in the cultivation of algæ especially those relished by the fish.

2. That further study be made on the practicability of transplanting dried lumut and lab-lab.

3. That studies be made to determine the relationship of the rate of growth of bangos to the rate of consumption of algæ.

4. That a more detailed research be done on the qualitative and quantitative analysis of planktonic organisms present in fishponds during the different seasons of the year.

TABLE 1.—*Collection records arranged as to places.*

C.R.	Date	Locality	Time	Weather	H_2O temperature	Air temperature	Salinity
1	12 June	Dagat-dagatan	9:00 A.M.	Cloudy	37° C.	32° C.	10
2	18 June	do	10:00 A.M.	Sunny	30° C.	29.5° C	10.5
3	25 June	do	9:00 A.M.	Showering	30° C.	28.7° C	7
5	2 July	do	9:00 A.M.	Sunny	29.9° C.	28.2 °C.	5.5
7	9 July	do	9:00 A.M.	Showering	31° C.	29° C.	5
9	15 July	do	9:00 A.M.	Sunny	35° C.	30° C.	8
10	23 July	do	9:00 A.M.	do	28° C.	27° C.	5.5
11	1 August	do	11:00 A.M.	Overcast	34° C.	28° C.	3
12	6 August	do	10:00 A.M.	Sunny	32° C.	31° C.	5
13	13 August	do	2:00 P.M.	Showering	34° C.	30° C.	0
14	20 August	do	2:00 P.M.	Cloudy	31° C.	28° C.	3
15	29 August	do	9:00 A.M.	do	31° C.	27° C.	2
16	3 September	do	10:00 A.M.	Sunny	29° C.	29° C.	0
17	10 September	do	10:00 A.M.	do	30° C.	28° C.	2
4	27 June	Camus F. P.	9:00 A.M.	do	30° C.	28.8° C.	8
6	1 July	do	10:00 A.M.	do	33° C.	30° C.	5
8	14 July	Meycawayan	10:00 A.M.	do	33.5° C.	30° C.	0

TABLE 2.—*Dagat-dagatan rearing pond.*

Kinds of algæ	12 June 1948	18 June 1948	25 June 1948	2 July 1948	9 July 1948	15 July 1948	23 July 1948	1 Aug.	6 Aug. 1948	13 Aug. 1948	20 Aug. 1948	27 Aug. 1948	3 Sept. 1948	10 Sept. 1948
Chlorophyceae.														
Enteromopha		x						x		x	x	x		
Chaetomorpha	xx	x						xx		xx	x		x	
Cladophora												x		
Pediastrum					x									
Myxophyceae.														
Anabaena		x												
Aphanocapsa														
Lyngbya			x		x	x	x							
Merismopedia														x
Microcoleus														
Nostoc														
Oscillatoria							x							x
Phormidium		xx												
Spirulina														
Bacillariaceae														
Achnanthes														
Amphiprora									xxx	x			x	
Asterionella				x										
Bascillaria														
Bacteriastrum				x										
Biddulphia	x			x	x	xxx	x			x	x	x	x	
Chaetoceras	x		xxx	x	x	x			x		x	x	x	
Corethron				x	x	x								
Coscinodiscus	xx			x	x	x	x				x	x	x	
Ditylum	x			x		x	x	x	x	x	x	x	xx	x
Gleocapsa														
Gyrosigma				x			x							
Hemiaulus	x													
Lauderia	x			x		x	x							
Mastogloia	x	x						xxx	x	x	x			
Melosira									x				x	x
Navicula				x	x		x		x	x	x	x	x	x
Nitzschia				x		x	x		x	x	xxx		x	
Planktoniella				x	x									
Pleurosigma	x				x	x	xxx	xxx	xxx		x	x	x	x
Rhizosolenia	x		x	x	x				x					
Stauroneis														
Surirella	x		x	x				x	x			x	x	x
Synedra	x					x					x			
Thallasionema														
Thalassiothrix	x			x		x								

TABLE 3.—*Dagat-dagatan nursery pond.*

Kinds of algæ	12 June 1948	18 June 1948	25 June 1948	2 July 1948	9 July 1948	15 July 1948	23 July 1948	1 Aug. 1948	6 Aug. 1948	13 Aug. 1948	20 Aug. 1948	27 Aug. 1948	3 Sept. 1948	10 Sept. 1948
Chlorophyceae														
Enteromorpha	----	----	----	----	----	x	x	----	x	----	x	----	----	----
Chaetomorpha	----	----	----	----	x	xx	xxx	xxx	xxx	xx	xx	xx	----	----
Cladophora	----	----	----	----	----	----	----	----	----	----	----	----	----	xxx
Pediastrum	----	x	----	----	----	----	x	----	----	----	----	----	----	----
Myxophyceae														
Anabaena	----	----	x	----	----	----	----	x	x	----	----	----	----	----
Aphanocapsa	----	----	----	----	x	----	----	----	----	----	----	----	x	----
Lyngbya	xx	xx	xx	xx	x	----	xx	x	----	xxx	xx	xx	xx	----
Merismopedia	----	----	----	----	----	----	----	----	----	----	----	x	----	----
Microcoleus	----	----	x	----	----	----	----	----	----	----	x	----	----	----
Nostoc	----	----	----	----	----	----	----	----	----	----	----	----	----	xxx
Oscillatoria	xx	----	x	xx	----	x	----	----	----	----	----	----	----	----
Phomidium	x	----	x	----	----	xx	----	----	----	----	----	----	----	----
Spirulina	----	----	x	----	----	x	----	----	----	----	----	----	----	----
Bacillariaceae														
Achnanthes	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Amphiprora	----	----	----	----	x	----	----	x	xxx	x	x	----	----	----
Amphora	----	----	----	----	----	----	----	----	----	----	x	----	----	----
Asteriastrum	----	----	----	----	----	----	----	----	----	----	----	----	----	x
Biddulphia	----	----	----	----	----	x	x	x	x	----	----	x	xxx	----
Chaetoceras	----	----	----	----	----	x	----	----	----	----	x	xxx	----	----
Corethron	----	----	----	----	----	x	----	----	----	----	----	----	----	----
Coscinodiscus	x	x	----	----	----	----	x	----	x	----	----	----	x	xx x
Ditylum	----	x	----	----	----	x	x	----	----	----	----	x	x	----
Gleocapsa	----	----	----	----	----	----	----	----	----	----	----	----	----	xx
Gyrosigma	----	----	----	x	----	----	----	----	----	----	----	----	----	----
Hemiaulus	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Lauderia	----	----	----	----	----	----	----	----	----	----	----	----	x	----
Mastogloia	xxx	x	xx	x	x	----	x	xx	x	x	x	x	----	----
Melosira	----	----	----	----	----	----	x	----	x	----	x	x	xx	xxx
Navicula	x	----	----	----	x	----	x	x	----	----	x	x	----	x
Nitzschia	----	----	----	----	----	----	----	----	----	----	x	x	----	----
Planktoniella	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Pleurosigma	xxx	xx	xxx	x	x	x	xxx	x	xxx	x	x	x	x	----
Rhizosoleni(	----	----	----	----	----	----	----	----	----	----	----	x	----	----
Stauroneis	----	----	----	----	x	----	----	----	----	----	----	----	----	----
Surirella	----	----	----	x	----	----	xxx	x	xxx	----	----	x	----	x
Synedra	----	----	----	x	----	x	----	----	----	----	----	----	----	----
Thalassionema	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Thalassiothrix	----	----	----	----	x	x	----	----	----	----	----	x	x	----

TABLE 4.—*Types of algæ in ponds and of algæ in the stomach and intestines of bangos.*

Kinds of algæ	Neighboring ponds				Stomach and intestinal contents				
	Camus pond	27 June 1948	Maycawayan	14 July 1948	Fish No. 1	Fish No. 2	Fish No. 3	Fish No. 4	Fish No. 5
Chlorophyceae									
Enteromorpha	x						x	x	x
Chaetomorpha	x	x		xx		xx	x		x
Cladophora				x			x		x
Pediastrum									
Myxophyceae									
AnAbaena				x					
Aphanocapsa									
Lyngbya	xxx	x		xx	x	x		x	x
Merismopedia		x							
Microcoleus									
Nostoc									
Oscillatoria	x							x	
Phormidium		x							
Spirulina									
Bacillariaceae									
Achnanthes					x		x		x
Amphora									x
Amphiprora				x					
Asterionella									
Bacteriastrum		x							
Biddulphia	x	x							
Chaetoceras	x	x							
Coconeis							x		
Corethron	x	x							
Coscinodiscus	x	x				x		xxx	x
Ditylum	x	x							
Gleocapsa									
Gyrosigma									
Mastogloia	xxx							x	x
Melosira		x		x			x	xxx	xx
Navicula	xx	x		x	xxx	x	x	x	x
Nitzschia		x							x
Lauderia		x							
Planktoniella		x							
Pleurosigma	xx	x		x	xxx	xx		x	
Rhizosolenia	xx	x							
Stauroneis									
Surirella	x	x							
Syendra									
Thalassionema									
Thalassiothrix	x	x							

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COMPARATIVE CAPACITIES OF VARICUS PLATING MEDIA FOR SATISFYING THE CULTURAL REQUIREMENTS OF AEROBIC BACTERIA IN MATERIALS OF MARINE ORIGIN.

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SUMMARY

Eight formulas of plating medium have been studied to determine their comparative abilities in satisfying the cultural requirements of the bacterial population in materials of marine origin. Five series of experiments comprising a total of 56 trials have been performed. The procedure and technique employed are thoroughly discussed.

Media prepared with "aged" sea water as menstruum were found to be definitely superior to those prepared with distilled water, alone or with NaCl.

The effect of different diluents, various plating temperatures of the medium and various incubation temperatures on the total bacterial colony counts were also investigated.

The principal problem which arises when planning any bacteriological investigation requiring quantitative bacterial determination in materials of marine source is the selection of a medium that gives the most nearly accurate picture of their bacterial population. Such a medium should satisfy the cultural requirements of a great number of microorganisms in the material under study.

The large number of nutrient media recommended for this purpose attests to the basic importance of an appropriate medium for enumerating marine bacteria. Comparative studies conducted by the Scripps Institution of Oceanography, on a large number of media which have been recommended by various workers show that medium 2216 (vide infra) is one of the best for supporting the growth of a maximum number of bacteria and for ability to reproduce the plate counts on marine material (ZoBell, 1946).

Fischer (cited by ZoBell, 1942) recommended a medium which differs slightly from 2216. This medium contains 1.0 per cent peptone and 0.5 per cent fish extract in sea water. ZoBell (1941), however, failed to produce any increase in plate counts by fortifying Medium 2216 with various fish extracts. Lloyd (cited by ZoBell, 1942) following experiments with ex-

tracts of various marine organisms including fish, states that they are not essential.

Bacteriologists of the Woods Hole Oceanographic Institution (cited by ZoBell, 1946) adopted the following formula which consistently gave them the best results:

Peptone	g.	1.0
Glucose	do	1.0
K_2HPO_4	do	0.05
Agar	do	15.0
Sea Water	cc.	1000.0

Berkeley, Lipmann, Bavendamn, Gee, and others (cited by ZoBell, 1942) used media containing nitrate. ZoBell (1941), using 0.005 to 0.10 per cent potassium nitrate, was unable to demonstrate any effect, "beneficial or detrimental" on the quantitative or qualitative plate count.

Kiser and Beckwith (1944) in their study of the bacterial flora of mackerel, compared mackerel infusion with 2216 medium for quantitative bacteriological examination and found the latter superior.

To the writer's knowledge no work on this particular phase of bacteriology has been conducted under local conditions. In view of the necessity of a suitable medium for making total and comparative counts of the shellfish-growing water and oysters from the Bureau of Fisheries oyster farm at Binakayan, in connection with investigations being conducted on these materials, the following series of experiments were performed.

MATERIALS

Media.—Eight formulas of plating medium were tried in this study.

Formula 1—2216 Medium

Bacto peptone	g.	5.0
Ferric phosphate	do	0.1
Bacto-agar	do	15.0
Sea Water ("aged")	cc.	1,000.0

pH not adjusted, about 7.6 after sterilization.[1]

Formula 2—Nutrient agar[2] with sea water menstruum

Bacto-beef extract	g.	3.0
Bacto-peptone	do	5.0

[1] All media were sterilized in the autoclave at 15 lbs. pressure for 20 minutes.

[2] Bacto-nutrient broth (Difco-dehydrated) was used with the other ingredients, as required in the formula, added.

Bacto-agar	g.	15.0
Sea Water ("aged")	cc.	1,000.0

pH adjusted to 7.8 before sterilization.

Formula 3—Nutrient agar with 0.5 per cent sodium chloride

Bacto-beef extract	g.	3.0
Bacto-peptone	do	5.0
Bacto-agar	do	15.0
Sodium chloride	do	5.0
Distilled water	cc.	1,000.0

pH adjusted to 7.8 before sterilization.

Formula 4—Nutrient agar with 15 per cent sodium chloride

Bacto-beef extract	g.	3.0
Bacto-peptone	do	5.0
Bacto-agar	do	15.0
Sodium chloride	do	150.0
Distilled water	cc.	1,000.0

pH adjusted to 7.8 before sterilization.

Formula 5—"Alamang" infusion agar.[3]

Alamang infusion	cc.	1,000.0
Bacto-peptone	g.	5.0
Bacto-agar	do	15.0

Adjusted to pH 7.8 before sterilization

Formula 6—Fish infusion agar.[4]

Fish infusion	cc.	1,000.0
Bacto-peptone	g.	5.0
Bacto-agar	do	15.0

Adjusted to pH 7.8 before sterilization.

Formula 7—Eyre's Oyster Agar (1944).[5]

Oyster infusion	cc.	1,000.0
Agar	g.	20.0

pH not adjusted about 7.6.

Formula 8—A modification of the formula recommended by the Woods Hole Oceanographic Institution.[6]

Peptone	g.	1.0

[3] Preparation of "alamang" infusion. To 500 g. fresh "alamang' (post-larval stages of Penaeidae) 1,000 cc. of "aged" sea water was added. The mixture was blended and infused overnight in the refrigerator, and then boiled and strained through cheesecloth and then through filter paper. The infusion was sterilized at 15 lbs. pressure for 20 minutes.

[4] The procedure for the preparation of fish infusion is the same as given for "alamang" infusion. Dalagang bukid (*Caesio caerulaureus*, Lacépéde) flesh was used, this being one of the most easily available at the time.

[5] The procedure was slightly modified by infusing the oysters in the refrigerator overnight instead of at 37° C. for 30 minutes. "Aged" sea water was used.

[6] The original formula calls for K_2HPO_4.

Glucose	g.	1.0
KH_2PO_4	do	0.05
Agar	do	15.0
Sea Water	cc.	1,000.0

pH not adjusted, about 7.6 after sterization.

Sea water.—Whenever sea water was required, filtered, sterile, "aged" sea water[7] was employed.

Source of specimens plated.—A total of 56 specimens were plated. Fifty of these were obtained from the Bureau of Fisheries oyster farm at Binakayan. These included 34 shellfish-growing water specimens and 16 oyster specimens. The other six included one of "aged" sea water, one of pooled "alamang" (postlarval stages of Penaeidæ), three of sea water obtained at the breakwaters in Manila Bay, and one specimen of pooled intestinal contents of "dalagang bukid" (*Caesio caerulaureus* Lacépéde).

All specimens were obtained and handled aseptically.

METHODS

Five series of experiments comprising a total of 56 trials were conducted. In each series a given group of media was examined for the number of bacterial colonies growing in each.

Preparation of specimens.—Ten-fold dilutions of the specimens were prepared with sterile "aged" sea water. One milliliter or fractions thereof of the two highest ten-fold dilutions was plated separately in each medium being compared in a given trial. Considerations calculated to facilitate an accurate enumeration of the bacterial colonies growing in the various media employed determined the choice of the dilutions plated. For instance, in the first few trials with oysters, 0.25 milliliter of a 1:100 dilution and 0.5 milliliter of a 1:1000 dilution were plated. Due to difficulties encountered in taking the counts in some of the plates, higher dilutions (0.25 milliliter of 1:1000 and 0.5 milliliter of 1:10,000) were tried and in the later trials still higher dilutions (0.25 milliliter of 1:10,000 and 0.5 milliliter of 1:100,000) were plated.

Technique for plating (plating temperature of media).—The technique evolved and employed was designed to reduce the actual temperature of the medium to a minimum without

[7] Fresh sea water filtered through paper and aged in glass bottles in the dark and at room temperature for at least three weeks before being used.

causing it to congeal before it was actually poured into the plate and mixed with the inoculum.

Duplicate tubes of each of the media under experiment were melted and kept in a 50° C. water bath. The petri dishes required (two for each media tested) were readied by pipetting into each the required amount of the appropriate dilution of the inoculum and each properly labeled. The tubes of media were taken from the water bath one at a time and cooled to body temperature by twirling continually in a breaker of cold water. The tube was further twirled a few seconds in air and the medium poured into the corresponding petri-dish. Then the inoculum and the medium were mixed thoroughly. By actual check, the temperature of the medium at the time of pouring ranged between 32° C. to 35° C.

Incubation temperature.—All culture plates were incubated at room temperature ranging from 23.5° C. to 27° C. taken at about 8:00 A. M. and 27° C. to 30° C. taken at about 3:00 P. M. during the period of these experiments.

Incubation period.—On the basis of observations made on preliminary trials, an incubation period of 96 hours for all inoculated plates was allowed before their corresponding colony counts were taken. This short period of incubation was adopted to minimize difficulties in taking accurate counts occasioned by the presence of spreaders which were frequently encountered in a good number of the media tried. Molds which become more troublesome after 96 hours and the rapid growth of some colonies in certain media which after 96 hours when close to one another usually coalesced and contributed their share of difficulty were avoided by this short period of incubation.

Observations made in this connection showed significant increases in the number of colonies up to about a week and that the plate indicating the highest count after 96 hours incubation generally gave the highest count after 7 days incubation.

Method of enumeration.—A direct total count of all the colonies in a plate was made whenever possible. When the colonies were close (over 300 to 400), the Quebec colony counter was used. After computing for the count per cubic centimeter (or per gram) of the undiluted specimen, the counts in the two dilutions in which the specimens were invariably plated, were averaged to obtain the final count per cubic centimeter (or per gram) of the specimen in each of the media tested.

To complement the data obtained in the series of trials performed under the subject of this investigation as indicated in the caption under which this report is being presented, the effects of the following factors on the bacterial colony counts were investigated.

1. *Diluents.*—Distilled water and physiological saline (0.85 per cent NaCl) were tried. "Aged" sea water was used as control diluent.

2. *Plating temperature of medium.*—Plating temperatures of 55° C., 50° C., and 45° C. were tried. The technique described above to attain a temperature of 32° C. to 35° C. in the plating medium at the time of pouring was used with the control plates.

Incubation temperature.—Incubation temperatures of 37° C. and 45° C. were tried. The controls were incubated at room temperature (vide supra).

In all these complementary experiments, the same procedure as discussed previously was employed, except where the particular variation under consideration was concerned. Medium 2216 was used in these trials.

RESULTS AND DISCUSSION

The eight formulas investigated had to be compared in groups of three or four owing to lack of adequate facilities. Five series of trials were run comparing a given group of formulas in each. Formula 1 was included in all the trials to afford a basis of comparison for all the formulas tested. The counts obtained in the individual trials are given in Table 1 and are expressed in per cent. A value of 100 per cent has been assigned to the count in Formula 1 and the proportionate percentage computed for the counts obtained in the other formulas in a given trial.

The results of the first trial illustrate the superiority of media with sea water as menstruum over those with distilled water as menstruum. Formulas 2, 3, and 4 are identical (vide supra) except for the menstruum employed and amount of sodium chloride in each. This observation conforms with those of ZoBell (1941, 1946), ZoBell and Feltham (1934), and others. Besides supporting the growth of very much fewer organisms, spreaders were particularly troublesome in Formula 3, both plates being completely overgrown with them making an accurate count impossible.

TABLE I.—*Bacterial counts in the various media tested.*

Media	Series I		Series II			
	1	2	3	4	5	6
Formula 1	0.100	100	100	100	100	100
Formula 2	3.22	96.58	64.54	62.5	267.62	69.76
Formula 3	(b)					
Formula 4	0.25					
Formula 5			54.32	84.61	247.12	50.95
Formula 6						
Formula 7						
Formula 8						

Media	Series III							
	7	8	9	10	11	12	13	14
Formula 1	100	100	100	100	100	100	100	100
Formula 2	78.39	22.85	80.00	50.00	26.07	58.73	23.68	81.37
Formula 3								
Formula 4								
Formula 5	59.79	21.42	153.00	50.00	34.95	19.04	24.56	18.06
Formula 6	45.22	22.85	40.00	8.33	37.82	25.39	27.19	46.06
Formula 7								
Formula 8								

Media	15	16	17	18	19	20	21	22
Formula 1	100	100	100	100	100	100	100	100
Formula 2	35.71	24.65	134.50	2.73	33.33	400.00	76.92	12.69
Formula 3								
Formula 4								
Formula 5	75.89	76.13	66.07	15.06	70.00	223.25	215.38	79.36
Formula 6	14.28	5.68	71.42	9.58	11.66	255.34	230.76	95.23
Formula 7								
Formula 8								

Media	23	24	25	26	27	28	29	30
Formula 1	100	100	100	100	100	100	100	100
Formula 2	61.19	8.39	28.57	45.55	24.00	39.58	374.61	21.31
Formula 3								
Formula 4								
Formula 5	27.79	10.58	33.03	11.48	32.00	45.88	51.02	63.93
Formula 6	27.79	3.05	6.25	32.76	22.00	18.75	83.46	36.88
Formula 7								
Formula 8								

Media	Series IV							
	31	32	33	34	35	36	37	38
Formula 1	100	100	100	100	100	100	100	100
Formula 2	140.38	40.34	36.36	11.71	65.56	1.19	13.82	76.82
Formula 3								
Formula 4								
Formula 5	76.92	48.92	14.54	1.17	50.40			
Formula 6	53.84	49.35	52.72	4.31	56.09			
Formula 7						1.40	1.34	31.63
Formula 8								

[a] All counts are expressed in per cent. See text for method of computation.
[b] Count not determined due to spreaders.

TABLE 1.—*Bacterial counts in the various media tested.*—Continued

Media	39	40	41	42	43	44	45	46
Formula 1	100	100	100	100	100	100	100	100
Formula 2	34.11	16.00	56.86	135.03	106.87	34.61	16.26	17.7
Formula 3								
Formula 4								
Formula 5								
Formula 6								
Formula 7	9.41	4.00	20.91	10.82	0	18.13	2.36	4.81
Formula 8								

Media		Series V								
	47	48	49	50	51	52	53	54	55	56
Formula 1	100	100	100	100	100	100	100	100	100	100
Formula 2	100	53.73	76.47	87.87	92.30	79.03	90.38	67.74	34.09	71.69
Formula 3										
Formula 4										
Formula 5										
Formula 6										
Formula 7	36.36									
Formula 8		83.58	47.05	98.48	96.15	46.77	67.30	156.45	101.13	56.60

The comparative values in per cent of the different media used in each of the series are given in Table 2. The values values given under individual series are averages of the percentage of values obtained for the various media in the trials run in that particular series. The figures in the column marked "final values" represent the final averages of the various serial averages obtained for a given medium where the latter was compared in two or more series (Formulas 1, 2, and 5), and where the medium was employed in only one series, the average obtained for the medium in that series (Formulas 4, 6, 7, and 8). Of the eight formulas investigated, Formula 1 apparently satisfies the cultural requirements of the greatest number of bacteria in the materials plated. Formula eight with an average bacterial count of 83.72 per cent is second in this respect. Then we have Formulas 5, 2, 6, 7, and 4 decreasing in average in that order.

While information on the comparative ability of the various media investigated to satisfy the cultural requirements of the

TABLE 2.—*Comparative values in per cent of the different media tested*

Media	Series					Final values
	1	2	3	4	5	
Formula 1	100	100	100	100	100	100
Formula 2	49.90	116.10	70.31	50.77	72.58	71.93
Formula 3	(a)					(a)
Formula 4	0.25					.25
Formula 5		109.25	57.57			83.41
Formula 6			48.07			48.07
Formula 7				12.85		12.85
Formula 8					83.72	83.72

[a] Not determined.

bacteria in the materials plated was the principal objective of this duty, observations on the following factors which may affect the number of colonies and/or facilitate their enumeration were made:

1. Uniformity in composition of batches of a given medium prepared from time to time.
2. Absence of obstructing precipitates in the medium after sterilization.
3. The growth of well defined, discrete colonies which do not tend to grow rapidly and coalesce,
4. Minimum growth of spreaders, bacterials or otherwise.

The ingredients which go into the preparation of Formulas 1, 2, 3, 4 and 8, with the exception of sea water whose composition is relatively constant (ZoBell, 1946), are standardized, and therefore, variations in the composition in batches of these media prepared at different times are negligible. Formulas 5, 6, and 7, however, call for infusions of "alamang", fish and oysters, respectively, whose inherent composition varies according to the source of the raw material and season of the year (Beck 1941) to mention only two factors which may influence the composition of the prepared medium. When properly prepared, Formulas 1, 2, 3, 4, and 8 were clear while varying amounts of precipitates were usually present in Formulas 5, 6, and 7 even after repeated filtrations before sterilization. Colonies growing in plates where any of the first group of media was used, were generally discrete and slow growers. This made possible easier and more accurate enumeration of the same than in plates where any of the second group of media, in which varying number of larger and faster growing colonies were observed, was used. No attempt, however, was made to determine whether the bacteria observed growing in the first group of media were of the same types as those growing in the second group.

On the basis of these observations, Formulas 1, 2, and 8 rank about the same and are superior to the rest of the formulas tried. The choice among these three media is therefore based on their comparative individual ability to meet the cultural requirements of the greatest number of bacteria in the materials plated (Table 2).

The results of the complementary experiments to determine the effect of various diluents, and varying plating and incubation temperatures on the total number of bacterial colonies are

given in Table 3. In general, they conform to the pertinent observations made by ZoBell (1941, 1942, 1946), ZoBell and Conn (1940), and ZoBell and Feltham (1935 and 1938).

Distilled water and physiological saline have a definite detrimental effect on the bacterial population when used for the preparation of the tenfold dilutions of the inoculum. Counts 41.89 per cent to 100 per cent lower were obtained when distilled water and physiological saline dilution blanks were used, or an average of 81.81 per cent and 60.97 per cent lower, respectively, than when "aged" sea water was used.

Plating temperatures of 55°C., 50°C., and 45°C. compared with the control plating temperature of 32° C., to 35° C. have definite, though less marked adverse, effects on the counts than distilled water and physiological saline diluents have compared with the corresponding controls. Counts 12.82 per cent to 64.70 per cent lower were obtained when plating temperatures of 55°C., 50°C., and 45°C. were employed, or an average of 30.87 per cent, 36.40 per cent, and 39.04 per cent lower, respectively, than that of the controls. The comparative closeness of the temperatures tried and the difficulty of insuring a uniformity of the factors affecting the rate of cooling of the medium after it is poured, however, has resulted in counts which while consistently lower than those obtained in the corresponding controls, show no definite trend in relation to the plating temperatures. These factors include, among others, the amounts of plating medium actually poured into the plate, the precise moment of contact between the inoculum and the plating medium and the rate and duration of rotation of the petri dish.

TABLE 3.—*Effect of various diluents, varying plating temperatures of medium and varying incubation temperatures on the total bacterial plate counts using 2216 medium.*

Trial	Control[a]	Diluent		Plating temperature			Incubation temperature	
		D.W.*	S.S.*	55° C	50° C	45° C	37° C	45° C
1	7,750[b]	500	1,000	4,250	6,750	4,500	2,750	1,500
2	8,500	0	3,500	6,500	3,000	4,750	5,750	500
3	12,500	2,500	5,500	7,250	6,000	8,250	6,750	3,000
4	85,750	12,250	49,750	74,750	72,000	54,750	79,250	43,250

* D. W. = Distilled water. S. S. = Physiological saline (0.85 per cent NaCl).

[a] The controls were prepared according to technique described under "Methods" using "aged" sea water diluent, a plating temperature of 32°–35°C. and room temperature incubation.

[b] Figures represent total bacterial count per 1 cc of the undiluted material.

Plates incubated at 37° C., and 45° C. show definitely lower counts than the controls which were incubated at room temperature. Counts 7.58 per cent to 80.64 per cent lower were obtained in plates incubated at 37° C. and 45° C., or an average of 37.61 per cent and 75.07 per cent lower, respectively, than those of the controls incubated at room temperature.

CONCLUSIONS

From the results obtained and under the conditions and limitations set forth in this paper, the following conclusions are drawn:

Formula 1, 2216 medium of ZoBell, satisfies the cultural requirements of the greatest number of bacteria in the materials of marine origin examined as evidenced by the counts obtained. This is, therefore, the most suitable among the 8 plating media tried for determining the total aerobic bacterial population in materials of marine origin.

Formula 8, a modification of the media recommended by the Woods Hole Oceanographic Institution in which KH_2PO_4 has been substituted for K_2HPO_4 which the original formula requires gave the second highest count. It is recommended as second choice.

While the counts in Formula 2 gave a lower average than those in Formula 5, the former is preferred to the latter due to the possibility of greater variations in composition and the presence of precipitates and frequency of spreaders in the latter. Formula 2, therefore, is recommended as third choice.

"Aged" sea water for preparing dilutions of the inoculum is definitely superior to either distilled water or physiological saline (0.85 per cent sodium chloride in distilled water) when the objective is for maximum plate counts.

A plating temperature of 32°–35° C. of the medium, attainable by a technique described, results in definitely higher counts than those obtained with plating temperatures of 55° C., 50° C., and 45° C.

Plates incubated at room temperature gave definitely higher counts than duplicate plates incubated at 37° C. or 45° C.

Significant increases in colony counts have been observed up to about 7 days' incubation at room temperature. Molds and spreaders, however, become correspondingly more troublesome with the increase in incubation period. Hence, where a com-

parative periodic check on the total bacterial count of a given material is the objective, the shorter incubation periods are to be preferred.

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